Proceedings of

ENTOMOLOGICAL SOCIETY of BRITISH COLUMBIA

Volume 51 **Issued November 30, 1954**

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OBSERVATIONS ON A BLACK FLY PEST OF CATTLE IN BRITISH COLUMBIA (DIPTERA: SIMULIIDÆ)*

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In Canada, particularly in the northern forested area, black flies are commonly regarded as a pest of man. However, there have been some notable outbreaks in Saskatchewan in which cattle were attacked with heavy losses. Cameron (1918, 1922) reported the loss of 100 head at Duck Lake in 1913, and indefinite losses at other times. Millar and Rempel (1944) described an outbreak at Macdowell, in which the loss was estimated at 132 animals valued at $20,000. Further outbreaks in 1945 and 1946 were dealt with by Rempel and Arnason (1947). All these attacks are attributed to *Simulium arcticum* Mall., but elsewhere large-scale attacks have been made by other species. Matheson (1950) summarized records of infestations affecting domestic and wild animals in the Danube Valley, and a wide range of domestic animals in the lower Mississippi region. Lohmann (1943) described injuries to cattle by black flies in Germany. This paper deals with an infestation of black flies in the Cherryville district of British Columbia in the years 1950–52.

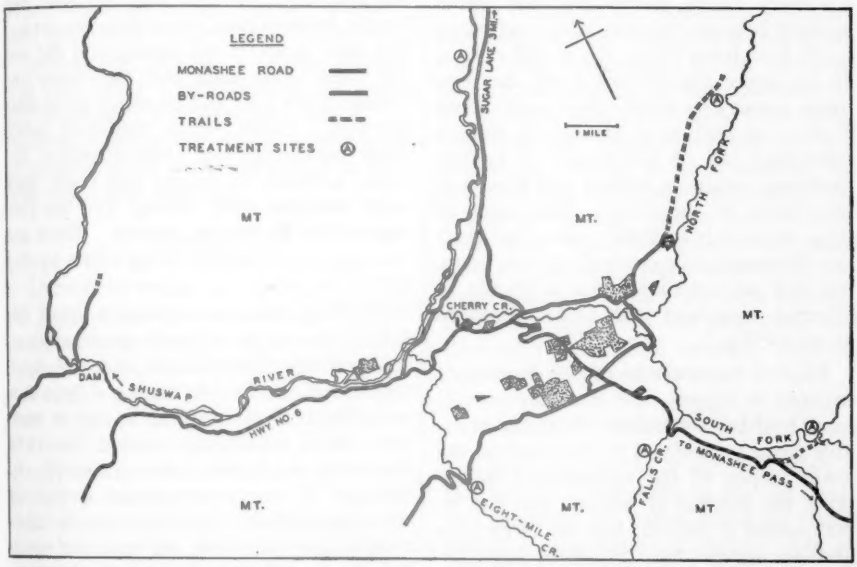

Fig. 1. Map of Cherryville (B.C.) district, prepared from aerial photographs. Stippled areas indicate clearings of home ranches.

The Problem

The Cherryville district (Fig. 1) lies in a valley on the western approach to the Monashee Pass in the Monashee Mountains, and is isolated from large centres of population and from other farming districts. The settled area is about 8 miles long and 3 miles wide, and is traversed by the Shuswap River and Cherry Creek.

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The part of the Shuswap involved in the present study originates in Sugar Lake, which it leaves through a storage dam maintained by the British Columbia Power Commission. It flows in a generally southerly direction for a few miles, swings west and north to a power dam at Shuswap Falls, then runs northerly to Mabel Lake through a sparsely settled valley. From Sugar Lake to the power dam is about 12½ miles. The flow in this stretch is regulated at the storage dam and varies from 700 to 3,000 cusecs according to power requirements. Throughout this part of its course, the river is wide and shallow, with a bottom composed of boulders and gravel.

Cherry Creek enters the river about midway between the two dams, and varies in its flow from 45 to about 400 cusecs. In its upper reaches the creek has two main streams — North Fork and South Fork — as well as a number of smaller tributaries, all of which rise in heavily timbered mountain valleys and flow rapidly down to the river. The water of these streams is relatively clear, but since the distances to be covered are not great, the lack of turbidity is not a barrier to effective treatment with DDT (Fredeen *et al.* 1953).

Most of the residents of this district are engaged in logging, but there are several small beef-cattle ranches. Since the available range is confined to the bush on the lower slopes of the surrounding mountains, the number of animals that can be maintained is limited, and the more progressive farmers have in recent years begun to specialize in raising pedigreed stock. Their animals are marketed at various bull sales and fat-stock shows, and prime condition is essential if good prices are to be obtained.

The black fly situation first became known to the staff at Kamloops in the late summer of 1951, when farmers complained that their animals were being attacked by an unknown fly that caused them to leave their wooded pastures for the open roadsides. The flies attacked the eyelids and the soft underparts, particularly the udders, so that the cows would not tolerate their sucking calves. The ranchers first became aware of this when the normally white-faced calves appeared with faces reddened with their mothers' blood. When questioned, most residents declared that the fly had been unknown until a few years previously, when it appeared in small numbers, later building up to pest proportions; a few even blamed its introduction upon passing migrant farmers and their outfits from the drought-stricken areas of the Prairies in the mid-thirties. However, some natives of the district stated that they had known the fly all their lives. It seems probable that the species is indigenous to the area, but that in earlier times, when ranchers turned out their stock in the spring and did not see them again until fall, they were unaware of the pest and its effect upon their animals. Later, when registered stock were introduced and their condition became a matter of dollars and cents, they were watched more closely and the ravages of the fly became known. There are no records of humans being bitten by this fly.

Although the area affected is small, the losses in weight of cattle attributable to this pest were considerable, and bore upon individual ranchers to such a degree that some doubted their ability to stay in business unless relief was obtained. In 1952 the local cattlemen's association (E. A. Rannie, *in litt.*) calculated a loss of $24,160 on beef animals alone, in addition to losses on bulls, the prices of which largely depend upon the results of judging in the show ring.

Adult flies taken from the cattle in 1951 were submitted to the Systematic Entomology Unit, Entomology Division, Ottawa, for determination; Mr. G. E. Shewell reported that, although the flies closely resembled *Simulium arcticum* Mall., they were of an apparently undescribed species.

In the spring of 1952 I examined the smaller creeks in the Cherryville district

and found no evidence of breeding. High water in the Shuswap River and Cherry Creek prevented thorough examination of these streams until mid-July, when both yielded pupæ that keyed out to *S. arcticum*. Adults reared from these pupæ were the same as those previously submitted to Ottawa. It is interesting to note that Hearle (1932) reported *S. arcticum* from several localities in British Columbia, including the Okanagan Valley, and Malloch (1914) gave Kaslo, British Columbia, as the type locality for this species. Mr. Shewell (*in litt.*) stated that he examined Hearle's British Columbia specimens and found them to be of *S. arcticum*, but a series taken by Hearle at Ione, Washington, and labelled *S. arcticum* conformed to the Cherryville species.

During 1952 Dr. W. R. Gunn, Provincial Live Stock Commissioner, requested the Provincial Entomologist, Mr. C. L. Neilson, to assist toward the achievement of control of the pest, and agreed to provide necessary materials.

Control

During the winter and spring of 1952–53 frequent visits were made to the area, and on March 1 a few early-instar larvæ were found in the Shuswap River, which then had a temperature of 38° F. None was found in Cherry Creek, which was 2 degrees colder. On March 17 the river was heavily infested, and the creek, which had risen in temperature to 39° F., had a few scattered larvæ in its lower reaches. By April 16 a few pupæ had appeared in the river, and DDT larvicide was applied without delay. Twenty-five per cent emulsifiable concentrate at one part of DDT in 10,000,000 for fifteen minutes (Hocking, Twinn, and McDuffie, 1949) was applied at a point 5½ miles above the mouth of Cherry Creek. In Cherry Creek the larvæ, with few exceptions, were still in the earlier instars. By May 1, pupæ were beginning to appear in the smaller creeks, and DDT at the same dosage was applied to both forks of Cherry Creek, Falls Creek, and Eight Mile Creek, at points indicated on the map (Fig. 1). These treatments removed practically all larvæ in the creeks, and in the river as far as the power dam at Shuswap Falls.

On June 26 Cherry Creek and the river below its mouth had become heavily reinfested, and the treatment of these waters was repeated. However, by this time the streams were in full freshet, and much larger quantities of larvicide were required than in the spring treatment. Two weeks later large numbers of larvæ were found in Eight Mile Creek, but these were quickly cleared out with DDT, and no more appeared in any waters of the district.

The results of the treatments appeared to be satisfactory. Whereas formerly the cattle were congregated in the day-time along roads and barns, and specimens of the black fly were easily taken from them, they were now scattered through the bush and, in the manner of range animals, unapproachable. Diligent sweeping of the foliage in suitable places produced no black flies. Ranchers interviewed stated that, although they had occasionally seen small numbers of flies on their animals, they were far below the pest level, and they were more than satisfied with the degree of control obtained.

Life-history and Habits

Little is yet known of the life-history of this fly. It overwinters in the egg stage, and hatching has taken place in waters having a temperature of 38° F. The reinfestation after the first treatment indicates that hatching continues over an extended period. Emergence of the adult flies, in the first two years of observation, was completed by mid-July, and the flies are reported by residents to be found from then until the first frosts. In contrast to the Saskatchewan outbreaks, which may occur as far as 100 miles from the breeding-sites (Rempel and Arnason, 1947), the species here discussed has not been reported more than 5 miles from streams in which it breeds.

This may be due to the mountainous and heavily timbered nature of the terrain. As a result of the work done in 1952, it was thought that this species, like *S. arcticum*, confines its breeding to comparatively large streams, However, the infestation of Eight Mile Creek, the maximum flow of which is 20 cusecs, implicates the smaller streams, and suggests that the upper reaches of the larger ones must be treated for satisfactory control.

Acknowledgments

The writer appreciates the assistance of the following: Mr. E. A. Rannie, Secretary, Cherryville and District Cattlemen's Association, for liaison with the ranchers; Mr. C. L. Neilson, Provincial Entomologist, for assistance in the field; Mr. J. Stewart, British Columbia Power Commission, Vernon, B.C., for providing data on the rate of flow of the Shuswap River; and the Provincial Department of Agriculture, which underwrote the cost of control measures.

Summary

A cattle-infesting black fly, closely related to *S. arcticum* Mall., caused serious loss of weight in beef animals in the Cherryville district of British Columbia. It overwinters in the egg stage; the first larvæ appear about March 1 and the pupæ in mid-April; adult emergence is complete by mid-July. Adults are on the wing for the remainder of the summer. A satisfactory degree of control was obtained with DDT, 25 per cent emulsifiable concentrate, applied at one part of DDT in 10,000,000 for fifteen minutes in near-by streams.

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●

NOTE

Ilybius inversus Shp. (*Coleoptera: Dytiscidæ*). Just too late to get into Hatch's "Adephaga," I took four specimens of the above species in a small lake at Barkerville, B.C. (4400 feet). The species is almost unknown in collections and was described by Sharp in 1882 from a specimen labelled merely "N.A." The insects are the size of our larger *quadrimaculatus*, strongly convex, somewhat pallid, and distinctly bronzed. Mr. J. B. Wallis verified two of the specimens.—*G. Stace Smith.*

CHEMICAL CONTROL OF THE PEAR LEAF BLISTER MITE, *ERIOPHYES PYRI* (PGST.), IN BRITISH COLUMBIA*

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In British Columbia the pear leaf blister mite, *Eriophyes pyri* (Pgst.), was first recorded from Agassiz in 1894 (Venables 1937). This mite is capable of causing severe damage to the fruit and foliage of pear, and to some varieties of apple, especially Newtown and Rome Beauty. The damage appears on foliage as blisters, as implied by the name of the mite. If the infestation is severe, early defoliation, and extensive russeting and cracking of the fruit may occur.

Although it may be satisfactorily controlled with a dormant application of lime-sulphur, information was needed on the susceptibility of the mite to acaricides applied at the pink bud stage. C. V. G. Morgan, of the Summerland laboratory, has shown (unpublished data) that the European red mite, *Metatetranychus ulmi* (Koch), may be more efficiently controlled at the pink bud stage than at the dormant stage. If the " pink " spray were adequate against the blister mite, it would have the advantage of simultaneously controlling both species of mites. However, at the pink bud stage most of the blister mites are present inside newly formed blisters on the young leaves. To be effective against them, a spray would have to penetrate the blister or the healthy leaf tissue. This is a report on the effectiveness of a systemic insecticide, the organic phosphate Systox (diethyl ethyl mercaptoethyl thiophosphate) and malathion applied at the pink bud stage and of common dormant sprays.

Methods

Four blocks of Newtown apple-trees, with a fairly uniform infestation of the blister mite, were selected for the experiment. Two blocks were sprayed with a Turbo-mist automatic concentrate sprayer and two with a high-volume hand-gun machine. Each orchard block was divided into eight plots; five were treated in March, during the dormant stage, and two in April, at the pink bud stage, one plot being left as a control. Records of leaf infestation were made in late summer by randomized sampling of 100 leaves from each of ten branches per tree, three trees being sampled in each plot of the four blocks. The materials, their amounts, and the stages at which they were applied are given in Tables I and II.

Results and Discussion

Results from the two hand-sprayed orchards are summarized in Table I and those for the two concentrate-sprayed orchards in Table II. The tables show that neither malathion nor Systox was effective against the blister mite at the pink bud stage, whether applied with a hand-gun or with a concentrate sprayer. In a previous experiment, 15 per cent parathion at 7.5 pounds plus lime-sulphur at 6.5 gallons per acre, applied as a pink bud spray, gave similarly poor control.

Dormant oil alone evidently gave little control of the blister mite. This is not in agreement with several authors (Quaintance 1916, Hawley 1926, Childs 1924). Childs stated that dormant oil is effective against the blister mite and that, since it kills by contact action, it must penetrate beneath the bud scales. Consequently, it is most effective when its viscosity is reduced by warm weather. Childs used an oil of 100–110 S.S.U. Vis. at 100° F., whereas in this experiment the oil was of 200–220 S.S.U. Vis. at 100° F. Perhaps the difference in oil viscosity was, at least in part, responsible for the difference in control. Childs

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Table I.—Percentages of Leaves Blistered by the Pear Leaf Blister Mite in Two Orchard Blocks in Which Various Acaricides Were Applied with a Hand-gun Sprayer at Two Stages

Stage	Acaricide	Amount per 100 Gal.	Amount per Acre	Percentage of Leaves Blistered		
				Block 1	Block 2	Average
Dormant	Lime-sulphur[1]	10 gal.	50 gal.	5	3	4
Dormant	Dormant oil[2]	2 gal.	10 gal.	9	2	6
	DNOC (40%)[3]	1.5 lb.	7.5 lb.			
Dormant	Dormant oil	2 gal.	10 gal.	8	4	6
	Lime-sulphur	4 gal.	20 gal.			
Dormant	Lime-sulphur	4 gal.	20 gal.	9	6	8
Dormant	Dormant oil	2 gal.	10 gal.	25	30	28
Pink bud	Malathion (25%)[4]	2 lb.	14 lb.	44	32	38
Pink bud	Systox (42.4%)[5]	0.25 pt.	1 qt.	46	42	44
	Check, no treatment	——	——	35	51	43

[1] Specific gravity 1.28. Oliver Chemical Company, Penticton, B.C.
[2] Viscosity 100° F., 200–220 S.S.U.; Shell Helix 29. Shell Oil Company, Penticton, B.C. Emulsified with soya-flour, 0.5 pound per 100 gallons.
[3] DN Dry Mix No. 2. Dow Chemical Company, Midland, Mich.
[4] Wettable powder. American Cyanamid Company, New York, N.Y.
[5] Diethyl ethyl mercaptoethyl thiophosphate; emulsifiable liquid. Geary Chemical Corporation, New York, N.Y.

Table II.—Percentages of Leaves Blistered by the Pear Leaf Blister Mite in Two Orchard Blocks in Which Various Acaricides (as in Table I) Were Applied with a Concentrate Sprayer at Two Stages.

Stage	Acaricide	Amount per Acre	Percentage of Leaves Blistered		
			Block 3	Block 4	Average
Dormant	Lime-sulphur	20 gal.	7	16	12
Dormant	Dormant oil	6 gal.	5	17	11
	DNOC (40%)	4 lb.			
Dormant	Dormant oil	3.8 gal.	19	22	20
	Lime-sulphur	7.7 gal.			
Dormant	Lime-sulphur	9.2 gal.	12	20	16
Dormant	Dormant oil	6 gal.	21	32	26
Pink bud	Malathion (25%)	12 lb.	56	48	52
Pink bud	Systox (42.4%)	1 qt.	51	31	41
	Check, no treatment	——	62	35	48

added that oil gives best results just after the buds have begun to burst. Presumably it is then able to penetrate more readily to the hidden mites. In the present experiment the oil was applied before the buds had started to open, and it may have been used too early for maximum effectiveness.

The other dormant spray mixtures, dormant oil-DNOC (4,6-dinitro ortho cresol), dormant oil-lime-sulphur, and the two concentrations of lime-sulphur, gave good control of the blister mite. High-volume hand-gun application was more effective than concentrate spraying, but the two methods are not comparable in that the high-volume method involved considerably more toxicant per acre. The dormant oil-DNOC mixture controlled the blister mite as well as the high dosage of lime-sulphur. This is useful information because the mixture is cheaper, is not so unpleasant to handle, and is useful against a greater number of orchard pests than lime-sulphur.

Summary

In high-volume spraying, the following dormant spray mixtures gave good control of the blister mite and were approximately equal in effectiveness: Dormant oil-dinitrocresol, lime-sulphur, and dormant oil-lime-sulphur. Dormant oil, 2 per cent, had little effect. A pink bud spray of the systemic insecticide Systox or of malathion had no effect on the blister mite. The control was not so good where the mixtures were applied with a concentrate sprayer as with a hand-gun sprayer, perhaps because lower amounts of spray materials per acre were applied in the former.

Acknowledgments

Thanks are due to Messrs. F. Seemungal, G. F. Lewis, and G. D. Halvorson, of the Summerland laboratory, for their assistance, and to Mr. C. V. G. Morgan for permission to refer to unpublished data.

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EX-PLANT QUARANTINE CHIEF DIES

A man who guarded B.C. crops against transported diseases for more than a quarter of a century has died in Kelowna.

Funeral of William Henry Lyne, former Chief of Plant Quarantine with the Department of Agriculture, was held from St. Michael and All Angels' Church, Kelowna, Archdeacon D. S. Catchpole officiating.

Mr. Lyne, who was born in Oxfordshire, England, came to Canada in 1890 and fifteen years later settled in Vancouver. He immediately joined the Department of Agriculture and then became plant quarantine chief until his retirement in 1933. A charter member of the Interstate Plant Quarantine Board, which held its first meeting at Riverside, Calif., in 1919, Mr. Lyne also was a member of British Columbia Entomological Society.

He is survived by his wife, residing in Kelowna; two daughters, Mrs. P. G. James, Kelowna, and Mrs. Donovan Allen, Vancouver; a sister, Mrs. E. Cleveland, New Westminster; a brother, J. H. Lyne, New Westminster; five grandchildren and one great-grandchild.—*Vancouver Province.*

STRAINS OF THE EUROPEAN RED MITE, *METATETRANYCHUS ULMI* (KOCH), RESISTANT TO PARATHION AND MALATHION IN BRITISH COLUMBIA.*

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In 1948 rose-growers in Connecticut and New Jersey encountered in their greenhouses a strain of the two-spotted spider mite, *Tetranychus bimaculatus* Harvey, that had become immune or resistant to parathion in an aerosol form (Smith and Fulton 1951). Since then there have been reports of orchard mites becoming resistant to parathion in the Pacific Northwest. O'Neil and Hantsbarger (1951) found a strain of the European red mite, *Metatetranychus ulmi* (Koch), in an orchard in the Wenatchee Valley, Washington, resistant to parathion. Newcomer and Dean (1952) reported the presence of strains of two species of mites resistant to parathion in the Yakima Valley, Washington, in 1951.

The first indication of parathion-resistant mites in the Okanagan Valley of British Columbia was noted in 1953. A grower in the Oliver district could not control an infestation of the European red mite with three sprays of 15 per cent parathion wettable powder, the first two sprays being applied at the recommended rate of 8 pounds per acre and the third at 12 pounds per acre. Numerous mites of all stages were found on the foliage four days after the last application. During the four previous years, this grower had applied, by hand-gun machine, an average of two sprays of parathion per year at 1 pound per 100 gallons per spray and had obtained satisfactory control. An experiment was conducted in this orchard to compare four non-phosphate acaricides with parathion and malathion. Ovotran, Aramite, and Sulphenone controlled the mites satisfactorily; DNOCHP gave good control for two weeks, but the mite population started increasing three weeks after the application (Table I). A week after the application it was evident that the control given by parathion or malathion was not adequate, although those two materials normally kill the mites very rapidly. The two plots were sprayed immediately again, DNOCHP being applied to the parathion plot and Aramite to the malathion plot.

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Table I.—Average Numbers of the European Red Mite per Leaf[1] before and after Applying Acaricides by Concentrate Sprayer in July, 1953

Acaricide	Amount per Acre	Before Spraying	After Spraying		
			1 Week	2 Weeks	3 Weeks
Ovotran, 50%[2]	8 lb.	17	4	1	0
Aramite, 15%[3]	12 lb.	19	3	1	0
Sulphenone, 50%[4]	20 lb.	39	9	3	1
DNOCHP, 40%[5]	2 lb.	23	3	1	3
Malathion, 55%[6]	5 pt.	48	19	Sprayed	
Parathion, 15%[7]	8 lb.	27	23	Sprayed	
Check, no treatment	———	13	8	10	7

1 Based on twenty-five leaves from each of four trees.
2 Para-chlorophenyl p-chlorobenzenesulphonate; wettable powder. Dow Chemical Company, Midland, Mich.
3 Beta-chloroethyl-beta-(p-tertiary butylphenoxy)-alpha methyl ethyl sulphite; wettable powder. Naugatuck Chemicals, Elmira, Ont.
4 Para-chlorophenyl phenyl sulphone; wettable powder. Stauffer Chemical Company, North Portland, Ore.
5 DN Dry Mix No. 1; wettable powder. Dow Chemical Company, Midland, Mich.
6 Penco Malathion E-55; emulsifiable liquid. Pennsylvania Salt Manufacturing Company, Tacoma, Wash.
7 Naugathion; wettable powder. Naugatuck Chemicals, Elmira, Ont.

Evidence of parathion-resistant mites also appeared in 1953 in a Summerland orchard that had received an average of two sprays of parathion per year since 1949. In 1953, 15 per cent parathion at 8 pounds per acre, applied in the pink bud stage, and 55 per cent malathion emulsifiable liquid at 4 pints per acre, applied in July, failed to control the European red mite. Normally, malathion at that rate controls the European red mite satisfactorily. A small experiment was carried out in this orchard to determine the relative value of parathion and of 19 per cent Mildex against the malathion-resistant mites. Mildex gave fair control, but parathion was entirely unsatisfactory (Table II).

A resistant strain of the European red mite also appeared in an orchard in the Penticton area. Fifty-five per cent malathion at two-thirds of a pint per 100 gallons, applied by hand-gun sprayer, did not control the mite, whereas 40 per cent Sulphenone at 3 pounds per 100 gallons did.

Table II.—Average Numbers of the European Red Mite per Leaf[1] before and after Applying Acaricides by Hand-gun Sprayer in August, 1953

Acaricide	Amount per 100 Gal.	Before Spraying, Aug. 5	After Spraying, Aug. 11
Mildex, 19%[2]	1 lb.	28	4
Parathion, 15%[3]	1 lb.	29	72
Check, no treatment	------	14	34

[1] Based on twenty leaves from each of two trees.
[2] Dinitro capryliphenyl crotonate and related nitrogen derivatives; wettable powder. Larvacide Products Incorporated, New York, N.Y.
[3] Naugathion; wettable powder. Naugatuck Chemicals, Elmira, Ont.

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SCIENCE NOTE

Note on Seed Production from Onion Bulbs Dipped in Insecticides at Planting

As the feeling that onion-seed crops were being damaged by maggots had persisted among growers in British Columbia, in 1953 tests were conducted to determine whether treatment of bulbs with insecticides immediately before planting affected: (*a*) The growth of the onion plants; (*b*) the amount of damage inflicted by the maggots, *Hylemya antiqua* (Mg.) and *Paragopsis strigatus* (Fall.); and (*c*) the subsequent yield and germination of the seed. The two species of flies were the most abundant of those collected over caged onion plants in the seed-fields at Grand Forks in 1950.

A farm at Kelowna where seed of the variety Yellow Globe Danvers No. 55 had been grown for many years was selected as the site for the tests. The experiment was conducted in randomized blocks with ten treatments, each replicated four times. Each plot consisted of one row 25 feet long; there were 36 inches between rows.

Treatments were 5 per cent slurries and 0.1 per cent emulsions of aldrin, DDT, dieldrin, and lindane. Bulbs were dipped in the slurries for five minutes and in the emulsions for thirty minutes. Slurries were prepared from wettable powders and emulsions from emulsifiable concentrates.

Two series of untreated plots were included; the bulbs for one were dipped in water for five minutes, for the other thirty minutes. These correspond to the periods of immersion for the slurry and emulsion treatments and compensate for any differences that might arise from the added moisture of the dip treatment. Eighty-five bulbs were planted in each plot. Counts were made of onion leaves two weeks after initial growth was observed. Periodic examinations were made throughout the season for phytotoxic symptoms and maggot damage.

All the seed-balls were harvested from each plot, stored in sacks until dry, threshed, blown, screened, and then weighed for seed yield. Four samples of 100 seeds each were taken from each treatment, placed on two thicknesses of filter paper in a closed petri dish, and allowed to germinate in a constant temperature cabinet at 78° F. Counts were made from the second to fourteenth day. Water was added when needed.

Analysis of variance showed no significant difference in growth, seed yield, or germination of onion seed produced. The average number of plants per treatment produced from the eighty-five bulbs per plot ranged from 79.7 to 84.2; the average seed yield ranged from 728.0 to 934.8 gm.; and the average percentage germination of the seed produced ranged from 95.7 to 98.0 per cent. No maggot injury was recorded in the experiment, although up to 35 per cent damage was recorded in near-by fields of onions grown from seed.

It must be assumed that the chemical treatment of the onion bulbs before planting had little or no effect on growth of the plants, or yield or germination of the seed.—*D. G. Finlayson, Field Crop Insect Section, Entomology Laboratory, Canada Department of Agriculture, Kamloops, B.C.*

HISTORICAL NOTE

While sorting the late Dr. E. C. Van Dyke's correspondence, I came upon a letter from Dr. H. A. Scullen of the Oregon Agricultural College at Corvallis, dated February 7, 1928. The following quotation may be of interest for the Entomological Society of British Columbia historical file:—

"Recently I was talking to Professor Livingston of our Department of Geology and found that his father was one of the early collectors in the region of Vancouver Island. His name was Clermont Livingston. Professor Livingston tells me that his father's collection consisted principally of Lepidoptera and Coleoptera collected since 1891 and is deposited with the Government House Museum at Victoria, B.C."—*Hugh B. Leech.*

A LIST OF HYMENOPTERA COLLECTED AT ROBSON, B.C.

H. R. FOXLEE
Robson, B.C.

FAMILY BRACONIDÆ

Earinus limitaris (Say), March, April.
Atanycolus anocomidis Cush., 1 VI 41, 22 VI 41.
sp., 10 VII 41.

FAMILY ICHNEUMONIDÆ

Scambus pterophori (Ash), 1 VI 46.
sp., 10 X 51.
Ephialtes imperator (Kriech), 13 VII 41.
manifestator (L.), 13 VI 41.
sp., 22 X 41.
Zaglyptus varipes incompletus (Cresson), 4 IX 51.
Perithous pleuralis Cress., 4 IX 51.
Pimpla pedalis (Cress.), 11 IV 41, 1 VII 51.
aquilonius (Cress.), 28 IV 46.
sanguinipes (Cress.), 24 VIII 41.
Itoplectis 4-cingulatus (Provancher), 5 VI 39, 2 X 39.
Rhyssa alaskensis Ash., 9 VII 39, 1 VI 46.
lineolata (Kirby), May.
Rhyssella nitida (Cresson), 26 V 46.
Megarhyssa nortoni nortoni (Cress.), 2 VI 46.
Xorides californicus (Cress.), 22 VI 39.
cincticornis (Cress.), 30 VII 39, 3 IX 51.
harringtoni (Rohwer), 13 VIII 39.
Odontocolon sp., 2 VI 40.
Coleocentrus occidentalis Cress., 22 VI 41, 4 VII 49.
Netelia (*Parabatus*) *deceptor* (Morley), 3 VIII 39.
Tryphon (*Symbœthus*) *communis communis* Cress., 19 V 51.
seminiger Cress., 19 V 51.
sp., 15 V 46.
Exyston sp., 16 VI 46.
Alegina apantelis (Cush.).
Endasys subclavatus (Say).
Phygadeuon sp., 1 VI 41.
Cubocephalus canadensis (Provancher), 10 VIII 41.
sp., 15 V 40.
Polytribax sp., 21 IX 41.
crotchii (Cresson), 27 V 46.
Rhembobius abdominalis pacificus (Harr.), 8 IV 42.
Cryptus altonii Dalla Torre, 7 IX 41, 1 VII 46, 5 X 41.
luctuosus (Cresson), 14 IX 41.
perplexus (Cresson), 28 IX 41, 16 IX 41.
Mesostenus thoracicus Cress., 22 VI 41.
Trychosis sp., 1 VI 41.
Idiolispa sp., 20 V 46, 1 VII 46.
Hoplocryptus notatus (Prov.), 28 VII 46.
Polistiphaga fulva (Cress.), ♂ 7 IX 41, ♀ 31 VII 41, 17 VIII 41.
Acroricnus stylator niger Mitchell, May, June, July, August.
Platylabus clarus (Cresson), 27 VI 41, 17 VIII 53.
pedatorius (Fab.).
Melanichneumon sp., 24 VIII 41.
Pseudamblyteles subfuscus (Cress.), 7 IX 41.
variegatus (Cresson), 17 VIII 41, 7 IX 41.
Amblyteles nubivagus (Cresson), 21 VII 43.
Ichneumon lætus (Brullé), 3 VIII 51.
sp., ♂ 24 VII 41.
sp., 3 ♂ ♂ 7 IX 41.
sp., ♂ 14 IX 41.
sp., ♂ 13 VII 41.
Cœlichneumon orpheus Cress., 21 IX 41.
Conocalama occidentalis occidentalis (Cresson), 1 VII 42.
Glypa phoxopteridis Weed, 13 VIII 39, 27 VII 51, 4 IX 51.
simplicipes Cress.
sp., 3 VIII 51.
Amersibia superba (Provancher), May.
Arenetra sp., 23 III 47.
Lissonota montana montana (Cresson), 7 IX 41.
sp., 21 IX 41.

Pimplopterus frigidus (Cress.), 7 IX 41.
sp., 21 IX 41.
Pimplopterus parvus (Cresson), 25 IV 51.
Syzeuctus eximius Walley, 6 VII 46.
Exetastes crassisculptus Cushman, April, May.
ridens Cushman, May.
ruficoxalis Cushman, 9 IX 40.
Banchus canadensis, Cress., May, June.
superbus Cress., April, May.
3 sps. probably, June, July.
Euceros sp., 13 VII 41.
Ctenopelma sp., 16 V 45.
Opheltes glaucopterus flavipennis (Provancher), 1 VII 42.
Synœcetes festivus (Cress.), 19 V 51.
Himerta flavida (Davis), 1 VI 41, 5 VII 51.
Mesoleius submarginatus (Cresson), 23 VI 46.
tenthredinis Morley, 1 VII 51.
sp., 29 V 51.
Hadrodactylus coxatus Davis.
Euryproctus sp., ♂ 2 ♀ ♀ 21 IX 41, 9 IX 51.
Cylloceria sexlineata (Say), 1 VI 41.
Diplazon lætatorius (Fab.), 29 VII 51.
Syrphoctonus sp., 5 X 41.
Chorinæus sp., 17 IV 51.
Leurus n. sp.
Triclistus fulvipes (Cress.).
Exochus flavifrontalis Davis, 6 IX 41.
Campoplex validus (Cresson), 5 V 46.
Campoletis atypicus (Vier), 3 V 51.
Campoletis sp., 1 VI 41.
sp., 5 V 51.
Phobocampe sp., 10 V 51.
Horogenes acutus (Vier.), 7 IX 41.
Anomalon reticulatum (Cress.), 24 VIII 41.
sp., 2 ♂ ♂ 24 VIII 41.
Aphanistes sp., 2 VI 46.
Gravenhorstia sp. No. 1, April, May, July.
Gravenhorstia sp. No. 2.
Gravenhorstia sp. No. 3.
Gravenhorstia sp. No. 4.
Labrorychus sp., 1 VII 51.
Therion circumflexum (L.), 20 VII 41, 13 VII 41.
morio (Fab.), 6 VII 46, 16 VI 40.
near *nigrovarium* (Brullé), 13 VI 41.
Ophion sp., 3 V 51.
sp., 2 VI 46.
sp., 1 VII 51.
Enicosphilus sp. (probably three species), May, June, July.

FAMILY GASTERUPTIIDÆ

Aulacostethus editus (Cresson).
foxleii Townes.

Acknowledgments

I wish to extend my grateful thanks to Dr. Stuart Walley, Division of Entomology, Ottawa; to Dr. H. K. Townes, Mutual Security Agency, Manila, Philippines; and to Mr. R. T. Mitchell, of the United States Fish and Wildlife Service, Laurel, Md., for determining all species listed in this paper. Without their kindly cooperation, it would not have been possible to write this list.

INSECT POPULATION SAMPLING*

K. GRAHAM† AND R. W. STARK‡

GENERAL CONSIDERATIONS

Purpose of Sampling

Sampling has four main functions:—

1. The *qualitative* determination of what is present within an area. This includes insects of taxonomic interest, noxious insects, and biotic agents of control, such as parasites and predators.

2. The *quantitative* determination of the status of a population within the area. It is desired to know the population levels of a particular insect, its parasites and predators. These determinations may be required to estimate the efficacy of artificial control. When done empirically, this is limited in scope and application to occasions requiring an immediate decision for treatment purposes or where interest or funds are not sufficient to make more detailed studies. Generally speaking, these are inadequate for determining success or failure of a control operation.

3. Usually, and particularly with those insects of economic importance, it is not sufficient to know only the present status of a population. It is also necessary to know something of the *dynamics* of the population; that is, what the population trends are when successive generations are studied.

4. In widely distributed insect populations it is often desirable and necessary to investigate the *ecology* of the species. This might include zones of abundance according to the locality, merely as a fact, or the abundance related to specific conditions such as physical environment or biotic community.

These four functions cover, in a broad sense, all of the purposes of sampling. The fields of sampling of the greatest economic importance and subject to the most error and criticism are the quantitative methods. Certainly, those methods dealing with the dynamics of insect populations are of the greatest use. From these stem reliable estimates of present and future insect damage, decisions as to the necessity for control, and information important to the application of biological or artificial control.

It seems timely to review some of the commoner sampling problems encountered in various fields of entomology, and the premises and techniques on which reliable sampling is based. Without suitable sampling we cannot use the tools of statistical analysis to describe the character of variability, to prove the reliability of estimates, or to show the significance of apparent differences. Therefore, it is the purpose of this discussion to review briefly the above considerations and illustrate them with samples from workers in the various fields.

Collection of Data

Everyone who studies insects has some need to sample even if it is in the empirical sense of the collector. Even he has to arrive at some decision as to the adequacy of a variable series. For example, most insects are not so constant morphologically that single specimens are truly representative of the species.

When it is a question of determining a population within a given natural universe and determining the mortality factors within it, the problems become much more complex. The most fundamental requirement is that *the sampling of a particular insect population must be resolved about the distribution and life-cycle of the insect involved.* There is no " universal " sampling method.

The environments of insects achieving economic importance comprise a tremendous variety, from onion-crops to mature

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forest stands, each of which has individual variations depending on age, density, site, shape, and other factors. In selecting the sampling technique to be followed, there are several factors to consider. At what stage in the life-cycle will it be easiest to sample, considering the eventual treatment of the data as well as more practical considerations such as economy. For example, nearly every insect has a stage that is more or less static. Samples taken during this stage lend themselves well to sound, and standard, statistical procedures in the treatment and interpretation of data. However, sampling of an immobile stage, although easier, may not be of sufficient value nor suited to the purpose of the investigation. This condition arises in artificial control programmes and where the expected trend from single sampling is desired.

A common problem is that populations, regardless of the stage sampled, are never distributed so uniformly throughout a sampling universe that a few observations can give a reliable indication of the average density. Obviously, neither mortality nor parasitism can be judged from single specimens. It is clear that there must be a compromise between the proportion of the sampling universe covered and the number of individuals examined (Oakland 1953). The spatial pattern of area coverage also affects the reliability of the estimate.

Accepting the fact that only an approximation of the truth must suffice, no matter how statistically sound, several problems are presented in seeking the nearest approximation to that truth with the greatest economy of facilities at hand. These are not so much in actual techniques as in the questions—where? how much? and how many?

Treatment and Interpretation of Data

To understand fully the requirements of sampling, the patterns of variability within a sampling universe must be considered. Much emphasis has been given to the concept of random sampling because it eliminates conscious or unconscious bias. There are many circumstances in nature, however, which make unrestricted random sampling illogical, especially where major subdivisions in the environment can be defined. In ecological studies it is often most logical to retain some homogeneity in terms of common features of environment. Thus one may wish to relate populations to restricted forest stands, field crops, individual orchards, and physical environmental factors such as altitude and aspect. This is often referred to as *stratification of sampling;* that is, sampling with respect to known environmental variates. Sampling in that manner is purposive and it has been demonstrated that within the confines of the stratum, sampling randomization can be attained to eliminate bias.

In summary, within any sampling universe there are two conditions of sampling that must be satisfied. These have been stated by Yates (1949), who writes:—

"1. If bias is to be avoided, the selection of samples must be determined by some process uninfluenced by the qualities of the objects sampled and free from any element of choice on the part of the observer.

"2. If a valid estimate of sampling error is to be available each batch of material must be so sampled that two or more sampling units are obtained from it. These sampling units must be a random selection from the batch of material, and all the sampling units in the aggregate must be approximately the same size and pattern and must together comprise the whole of the batch of material."

Personal selection, such as a tendency to over- or under-estimate and a tendency to select for particular characteristics, biases the estimation of the mean, and the standard errors derived for these estimates are meaningless.

A word of caution is advisable. The form of analysis of the data depends upon the sampling method used and upon the proportion of the population sampled. This subject is too detailed to include here but is simply and adequately covered

in the elementary text by Quenouille (1950).

It has been shown by various authors and is fully discussed in Quenouille that the arithmetic mean of a sample gives a more accurate value for the mean of the population than any other measure, and that the standard deviation will usually give a more accurate measurement of the scatter in a population estimate than any other value. Moreover, most of the properties of a sample can be found from its mean and standard deviation. However, it must be borne in mind, when presenting data, that other expressions of central tendency and scatter, such as the mode, quartiles, deciles, and range, may illustrate a point better.

There is a further point to remember when sampling. Because the objective is to establish the character of the population in general, an attempt is made to estimate the frequency distribution of that population. In biological work it is often possible to estimate the general form of the distribution from field observations prior to sampling and hence to find the type of distribution with a smaller sample.

A distribution which often occurs, but, alas, not so frequently in biological work, is the *normal distribution*. When this applies it is indeed fortunate, for the mean and variance can be used to determine *all* about the population. This is the perfect case, making it simple to present the proportions of observations between any two values in summary form. However, as was stated, this does not obtain frequently in biological populations. Much work has been done in the field of biometrics, and it is not intended here to present a capsule digest, since this would be impossible. All that can be hoped is to stimulate interest and provide references to satisfy that interest.

In biological work, particularly entomology, there have been several population distributions described to suit particular cases. These include Poisson, binomial, negative binomial, Fisher's logarithmic, Neymann's, Cole's, the Thomas double Poisson, and Polya's. In regard to these, attention is called to a recent article which is, in our opinion, the most valuable single contribution in this field in recent years. This is an article by C. I. Bliss and R. A. Fisher (1953). In addition to demonstrating with examples the fitting of this distribution, they illustrate its advantages by comparison with the major types of distributions in use. Furthermore, they supply the reference sources for them. The article is well written and easily readable by anyone with a basic grasp of statistics, and it indicates that the problem of non-random biological distributions is being attacked from the view-point of the man who is faced with the problem; viz., the biologist.

The importance of distributions in quantitative sampling work has arisen from the fact that the statistical tests for significance of data, and, more important, the comparison and interpretation of data such as the variance-ratio test, are largely based upon the normal distribution. To be able to assess and accurately compare the characteristics of a population that is not normally distributed, the distribution must be related in some way to the normal distribution. This brings up the use of *transformations* to fulfil the above requirement. This cannot be elaborated upon here, and again reference is made to more qualified sources. Quenouille contains an easily understandable discussion on the subject, and one other reference of value is the article by Churchill Eisenhart (1947).

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FOREST DEFOLIATORS*

Forest-insect population studies during the past decade have shown increasing recognition of the fact that valid conclusions regarding population trends require measurements made within certain limits of accuracy. The value of population estimates and trends is obviously enhanced if these can be related to actual forest damage. Not only the populations of the destructive insects, but also those of their parasites and predators are important. Indeed, all the mortality factors, such as climatic extremes and disease must be accounted for in the most valuable population studies.

There are many examples in the literature of population sampling. De Gryse (1934) described the most important techniques extant in 1934, but there have been many important advances since that time. For illustrative purposes only, three examples are presented which will serve to demonstrate the methods involved and practical applications.

European Spruce Sawfly

This example is drawn from the work of M. L. Prebble (1943), who determined populations of the European spruce sawfly in the Gaspé Peninsula. This exhaustive and detailed work discussed the general requirements of sampling forest insects, demonstrated the difficulties encountered in this particular study, and showed how they were surmounted. The conclusions, based on eight years of field data, pertain solely to the sampling methods applicable to the cocoon stage.

It has been mentioned that choosing the stage of insect to be sampled is of great importance. The most desirable objective is the sampling of all stages related to a common denominator. In the spruce-sawfly work, larval population studies were carried out, but the amount of work required seriously limited their applicability. However, they are of value for long-term ecological studies, such as will be mentioned in a later example. It was determined that the cocoon stage, spent in the moss and debris of the forest floor, was best suited for sampling. It gave the maximum information on sawfly populations as well as the various control factors operating against the cocoon stage. Furthermore, the forest floor constituted a sampling universe that could be statistically regulated.

Three techniques were tested. The first consisted of counts of cocoons in 2- by 2-foot quadrats spaced mechanically and uniformly within representative forest types, regardless of suitability of location of individual quadrats. The second, using the same size of quadrat, required their location in a restricted universe, which was defined as "the area of suitable ground cover lying under dominant and codominant spruce trees in the forest types selected for study." The quadrats had to lie within a ring-shaped band whose inner margin was a circle around the tree 1 foot from the trunk and whose outer margin was bounded by the outer edge of the vertical projection of the crown. The third method used the same restricted sampling universe but divided the quadrats into four equal subsamples. This was tantamount to quadrupling the number of samples in the statistical analysis, although it introduces certain disadvantages. The manner of devising the latter two methods indicated that an *a priori* knowledge of the distribution in the forest floor assisted in reducing the required number of samples.

The first technique was abandoned, as it was found from analysis that the variability was so high that the number of samples necessary to give an accurate estimate was beyond practical limits. Both the second and third methods proved usable, but disadvantages in statistical interpretation were found in each. Without elaborating on these, it was concluded that where successive samples were to be taken in the same plot, the second method was the better; i.e., using the tree as a sampling unit. This would be usual prac-

* This section written by R. W. Stark.

tice when we are interested in population fluctuations.

An interesting side investigation reported in this paper was a comparison of the variability between the efficiency of workers. Its purpose was to determine the advisability of applying a correction factor to account for missing cocoons. No correction was needed, but checks were necessary to bring the counts to a satisfactory degree of accuracy.

An additional reference of interest is the discussion by Butcher (1951) of forest-insect sampling problems with special reference to the larch sawfly, whose habit of overwintering in cocoons in the soil renders the sampling problem similar to that of the spruce sawfly.

The Lodgepole Needle Miner

Intensive study of this insect began in 1948, and it was 1951 before adequate sampling methods were derived. Graham, in 1951 (1952), presented to this society the ecological aspects of the problem; therefore, only methodology will be discussed here.

Statistical analysis in 1951 demonstrated that early coverage of the outbreak in the National parks was almost empirical. However, this analysis did provide the *a priori* knowledge, so often useful, for more efficient work. It demonstrated the practicability of using the branch tip as a sampling unit and indicated how many samples would be required to give a sampling accuracy of 10 per cent. Because a leaf-mining insect was involved, choice of the stage to be sampled was not the difficult problem that it is with most open leaf-feeders.

In the summer of 1951 four branch tips from each of 105 trees were sampled to establish the sampling method. This number of trees was predetermined only approximately; sampling was continued until the error was below 10 per cent. The sampling was done with respect to altitude, and it was established, population-wise, that we may consider three sampling universes with respect to altitude and two with respect to pine-trees. This was established from an analysis of variance between crown levels (arbitrarily dividing the crown into upper and lower, the division at the midpoint) and three altitude levels—valley-bottom (approximately 5,000 feet), valley-bottom plus 750 feet, and plus 1,500 feet. In the Rocky Mountains the latter elevation is usually close to timber-line. From the analysis of these samples it was determined that the counts of live larvæ in the sampling unit of a five-year branch tip were acceptable, and that, for practical usage, four branch tips from approximately thirty trees would give absolute population estimates within 10 per cent accuracy (Stark, 1952(*a*)). This was applicable to all stages found in the needle, from first instar to pupæ. However, to compensate for extremely high values in the low infestation counts, a transformation of the data was required. The transformation was supplied by G. B. Oakland, of the Biometrics Unit, Ottawa, as $\sqrt{x+0.5}$, where x is the individual sample. Analysis of the transformed data corroborated the assumption that the distribution was, in effect, normal. More important, use of the transformation made possible a new application of the sequential sampling technique (Stark, 1952(*b*)).

The sequential formulæ were supplied by Oakland for the normal distribution. This technique is proving extremely useful in lodgepole-needle-miner surveys. Briefly, it is sampling with no fixed sample size. Limits of infestation classes and tolerated error are set, and the appropriate formulæ are applied. What is arrived at is graphical (or tabular) limits composed of upper and lower acceptance levels. Sampling is continued until the cumulative sum of samples is smaller or larger than the acceptance levels, thereby falling into an infestation "class," i.e., light, medium, etc.

The first system set up for the needle miner was arbitrary. Classes were called light, medium, and heavy, and were set with respect to existing populations. It has since been possible to relate infesta-

tion classes to the amount of defoliation, and new limits for needle-miner sampling by this method are being established. This will greatly increase the value of this method as a survey tool.

Spruce Budworm

Because of its complex life-history and habits, development of sampling methods for this forest defoliator has proved to be a most difficult problem. However, after years of research it has been largely resolved and is being dealt with fully in other papers now in the process of publication. Only a brief résumé of the problems involved and a few of the results will be given here.

It was found that the egg-masses of the budworm constitute a sampling unit that is satisfactory from points of view of ease of collection, examination, and statistical analysis. This was not true of the first two instars, particularly the first. In both instars there is considerable wandering and wind dispersal, and the first-instar larvæ hibernate in tiny well-concealed hibernacula. These factors do not permit direct field sampling. When counting was required, samples had to be brought into the laboratory, and the larvæ were forced to emerge. The third to sixth instars are open feeders, reasonably limited in movement. As these may be found together in the field, they are considered as one sampling stage. Similar direct sampling of pupal cases gives information on pupal mortality factors and, indirectly, on moth populations and sex ratio, since sex of the moth may be determined from empty, as well as sound, pupal cases.

The physical problems of sampling for budworm were also great. In large trees, when felling was resorted to, the loss of larvæ and particularly of pupal cases was often large enough to affect sampling accuracy. To surmount this the investigators resorted to sectional aluminium pole pruners and an extensible aluminium ladder. The use of these in sampling was described by Morris (1950).

One notable achievement is the relation of all stages of the insect to a common denominator, the mean number of individuals per 10 square feet of foliage surface. This permits direct comparisons of all stages, important in ecological studies, and also allows conversion of populations at any stage to estimates of absolute populations.

The sample branches are whole primaries, the width and length are measured, and the area estimated allowing for branch shape. Special sampling by vertical and horizontal crown sections was used to establish the distribution and variance of the population in the tree (Morris, 1949).

It is understood that a successful application of the sequential technique has been applied to the spruce budworm, based on a different distribution than that described for the needle miner.

These examples serve to illustrate the advancements made in sampling forest defoliators within the past decade. The pattern of scientific investigation has been similar in all three examples and gives promise that the problems in sampling which are fundamental to further studies of the causes of insect fluctuations may yet be resolved.

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——— Sequential sampling of lodgepole needle miner. For. Chron. 28:57–60. 1952 (*b*).

NOTES ON THE LIFE-HISTORY OF *HESPERIA COMMA* L. *MANITOBA* SCUD. (LEPIDOPTERA, RHOPALOCERA) ON VANCOUVER ISLAND

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The following notes are supplementary or confirmatory to what is known concerning the life-history of this skipper. I am not aware that the life-history has been worked out for the Vancouver Island representative of the species.

Ova can easily be obtained by confining a female under a sleeve of netting enclosing a tuft of grass. She will lay her eggs on the grass, netting, and the twigs supporting the net. One female thus confined laid forty eggs. Another group of three laid fifty eggs within a day or two.

Egg. — Size 1 mm. by 0.80 mm. Hemispherical, attached to the grass by the broad base; smooth, slightly depressed in micropylar area, and with fine microscopic reticulations. Colour, a dull chalky white.

The following notes were obtained by observing the development of one individual from egg to adult. A female was observed fluttering slowly about the grass in a neglected corner of my lawn in a manner very different from the usually swift and erratic flight common to the skippers. After a short time she settled well down at the base of a grass stem and, curving her ovipositor forward, made one or two trial thrusts before depositing an egg on the stem. She then fluttered a short distance away and repeated the process. I collected an egg and placed it in a glass tube where the subsequent metamorphosis took place.

As the larva developed very slowly during the early phases, the moults were not all observed with certainty, hence a chronological account follows:—

September 19, 1952. The egg, laid on dead grass stem, was placed in a glass tube for observation.

April 24, 1953. Egg hatched. Larva, 2 mm. in length; head very large in proportion to the rest of the body, jet black; body fairly stout, spindle-shaped, pale beige or putty colour.

April 29. Larva very sluggish but nibbles sparingly at the grass.

May 23. Length 4 mm. Since April 29 it seems to have had only one moult. It spends most of the time in a slight silken cell constructed among the grass blades, from which it makes sorties in search of food.

May 27. As before. I have to keep on changing the grass, very carefully placing the fresh food alongside the cell, as the larva does not venture far away.

June 5. Length, 5 mm. Head black, roughened with minute papillæ. The first thoracic segment very small and narrow and looks like a black ring round the body. Body putty-coloured, thickly dotted with tiny black papillæ. Prolegs black, claspers same colour as body. Two white spots on under-side between segments 10-11 and 11-12. Under the microscope these spots appear to be made up of finely shredded white scales.

July 1. Length, 8 mm. Probably in third moult. Although growing slowly, the larva is evidently in good condition. Colour and markings as before.

July 14. Length, 17 mm. Obviously growing faster as size increases; remains most of the time within its cell, which is enlarged to match growth.

July 18. Length, 20 mm. I saw the larva in the process of moulting. Colour is darker.

August 7. Length, 30 mm. Possibly the fifth moult. Head black with two light-coloured vertical marks on vertex. Surface of head roughened with minute papillæ, body smooth, dull buff colour.

August 11. Length, 30 mm.; width, 6 mm. Evidently in last moult. Body reddish, spiracles black.

August 16. Size as before. Body has a tinge of brownish-purple with an obscure dark dorsal line.

August 24. Pupated in the last larval cell. **Pupa:** Length, 20 mm.; width, 6 mm. Wing-cases bluish-black, abdominal segments a dull pink, each segment with a double row of transverse fuscous dashes. Cremaster a tuft of many outwardly recurved hooked hairs. The pupa reposed in the cell vertically, head uppermost.

September 17. Pupa much darker in colour, the transverse abdominal markings have become merged into the general ground colour.

September 19. **Imago** emerged from the pupa exactly one year from the day the egg was laid. The adult was a female, normal as to size and colour.

Summary

The skipper *H. comma* L. *manitoba* Scud. passed a period of seven months in the egg stage, i.e., September 19, 1952, to April 24, 1953. The larval period required four months; growth was remarkably slow in the early stages. When feeding, the larva never went far from its silken cell unless the food-supply ran out, then it built a new cell among fresh growth, *Lolium* and *Bromus* sp.

I was unable to ascertain what function, if any, the four white spots on the underside of the larva may fulfil, although they seem to be of a structural nature rather than due to pigmentation. Could they be scent glands?

The pupal stage lasted for one month, and the pupa was enclosed in the old feeding tent of the larva, an unusual feature in butterfly pupæ.

CHEMICAL CONTROL OF APHIDS IN BRITISH COLUMBIA ORCHARDS*

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Field experiments were conducted from 1947 to 1953 on the chemical control of the following aphids that attack tree fruits in the Interior of British Columbia: The black cherry aphid, *Myzus cerasi* (F.); the mealy plum aphid, *Hyalopterus arundinis* (F.); the thistle aphid, *Anuraphis cardui* (L.); the green peach aphid, *Myzus persicæ* (Sulz.); the apple aphid, *Aphis pomi* Deg.; and the woolly apple aphid, *Eriosoma lanigerum* (Hausm.). The work was done primarily to keep the pest-control calendar up to date in aphid-control.

Sprays Directed against Overwintering Eggs

Since 1944 a spray of heavy dormant oil with DNOC or DNOCHP has been recommended in the Interior of British Columbia for the control of orchard aphids that overwinter in the egg stage. O'Kane and Baker (1935) have shown that oils kill aphid eggs by penetrating the egg-shell rather than by suffocation. Consequently, tests were conducted on a dormant application of other insecticides dissolved in dormant oil. In 1948 and 1949 a series of experiments with high-volume hand-gun sprayers on the control of the mealy plum aphid and the thistle aphid on prune-trees and the black cherry aphid on cherry-trees showed that parathion-dormant oil and BHC-dormant oil were just as effective against these aphids as the standard treatment of DNOC (or DNOCHP)-dormant oil. The results of a typical experiment are shown in Table I.

In some experiments, parathion alone, 0.75 pound of 15 per cent wettable powder per 100 gallons, applied at the dormant stage of bud development, also gave very good aphid-control (Table IV).

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Table I.—Numbers of Colonies of the Black Cherry Aphid on Bing and Lambert Cherry-trees after a Dormant Oil Spray Containing Parathion, BHC, or DNOCHP

Material	Amount per 100 Gal.	Colonies per 10 Trees 67 Days after Spraying
Parathion, 15% wettable powder[1]	1 lb.	0
Dormant oil[2]	1 gal.	
Soya-flour[3]	1 lb.	
BHC, 10% gamma isomer, wettable powder[4]	0.25 lb. gamma isomer	3
Dormant oil	1 gal.	
Soya-flour	1 lb.	
DNOCHP, 40% wettable powder[5]	1.5 lb.	4
Dormant oil	1 gal.	
Soya-flour	1 lb.	
Check	No spray	137

[1] American Cyanamid Company, New York, N.Y.
[2] Approximately 220 S.S.U. Vis. 100° F., 65 per cent U.R. Shell Oil Company, Penticton, B.C.
[3] Sprasoy. Glidden Paint Company, Chicago, Ill.
[4] Pennsylvania Salt Manufacturing Company, Tacoma, Wash.
[5] 2-cyclohexyl-4,6-dinitrophenol. Dow Chemical Company, Midland, Mich.

Although parathion, alone or with dormant oil, and BHC-dormant oil were just as effective as the dinitro compounds with dormant oil, they were not recommended for aphid-control because the dinitro-oil formulations have the additional advantage of being effective against overwintering larvæ of the eye-spotted bud moth, *Spilonota ocellana* (D. & S.) and overwintering stages of some species of orchard mites.

Sprays Directed against Nymphs and Adults

Parathion. — For many years the recommended spray for the summer control of several species of orchard aphids in British Columbia was nicotine sulphate mixed with soap or summer oil. However, with high-volume hand-gun spraying, nicotine did not always give satisfactory control. Consequently, when parathion became available, it was compared with nicotine for the control of several species of aphids.

Light to medium infestations of the mealy plum aphid on prune-trees were controlled more satisfactorily with parathion than with nicotine sulphate-soap (Table II), but the entomologists and a number of growers found that neither of these sprays gave satisfactory results when the aphid infestation was severe (Morgan and Downing, 1950).

Table II.—Percentage Mortalities and Numbers of Colonies of the Mealy Plum Aphid on Italian Prune-trees after a Summer Spray of Parathion or Nicotine Sulphate

Material	Amount per 100 Gal.	Per Cent Mortality		Average Number of Colonies per Tree	
		Orchard 1[1]	Orchard 2[2]	Orchard 3[3]	Orchard 4[4]
Parathion, 15% wettable powder[5]	0.75 lb.	100	100	0.0	0.3
Nicotine sulphate, 40% liquid[6]	0.75 pt.	99	85	0.5	6.8
Soap[7]	3.0 lb.				
Check	No spray	9	15	6.0	22.0

[1] Based on 1,500 aphids per treatment, forty-eight hours after spraying. Four trees per treatment.
[2] Based on 1,000 aphids per treatment, ninety-six hours after spraying. Three trees per treatment.
[3] Based on sixteen trees per treatment, thirty-one days after spraying.
[4] Based on four trees per treatment, twenty-four days after spraying.
[5] Canadian Industries Limited, Montreal, Que.
[6] The N. B. Bartlett Spray Works, Beamsville, Ont.
[7] Rinso. Lever Bros., Montreal, Que.

In an experiment on the control of a severe infestation of the thistle aphid on prune-trees, parathion and nicotine sulphate-soap, used at the same dosages as in Table II, each killed over 99 per cent of the aphids when the sprays were applied during the summer by high-volume hand-gun machine.

Table IV shows that, with high-volume hand-gun spraying, parathion gave better control of the black cherry aphid than nicotine sulphate-soap when the sprays were applied at 95 per cent petal-fall of cherry. The superiority of parathion over nicotine sulphate-soap for the control of this aphid was even more evident in summer applications. For example, forty-nine days after spraying by high-volume hand-gun machine, the average number of aphid colonies or infested twigs per tree was forty-five in the nicotine plot but only five in the parathion plot.

In one experiment, with a high-volume hand-gun machine, the green peach aphid was controlled as satisfactorily with 15 per cent parathion, 1 pound, as with 40 per cent nicotine sulphate, 1 pint, plus washing soda, 0.5 pound, per 100 gallons of spray. In another experiment, with a high-volume hand-gun machine and with

a semi-concentrate machine, neither parathion nor nicotine was satisfactory against the green peach aphid. Control was somewhat better with high-volume spraying than with semi-concentrate spraying. Poorer results in the second experiment were partly due to unfavourable weather; the temperature was relatively low (60° to 65° F.), it was windy, and rain fell before the spray deposits were dry.

Parathion gave rather good control of the woolly apple aphid when used at 1 pound of 15 per cent wettable powder per 100 gallons, but was much less effective at 0.5 pound. Control was improved by the addition of stove oil or summer oil. For example, in one experiment with a concentrate sprayer, parathion, at 3 pounds of 25 per cent wettable powder per acre, alone and with stove oil at 2 gallons per acre, was compared with 40 per cent nicotine sulphate, 1 gallon, plus summer oil, 2 gallons, per acre. Five days after spraying, the average number of aphids per internode was: Nicotine sulphate-summer oil, 0.1; parathion-stove oil, 0.2; parathion, 4.7; check, 286.4.

Parathion proved much more injurious to predacious coccinellid and syrphid larvae than nicotine sulphate, and was very toxic to aphid parasites. In a field experiment on the control of the black cherry aphid, parathion was applied by high-volume hand-gun sprayer at 0.75 pound of 15 per cent wettable powder per 100 gallons. Forty-eight hours after spraying, the parathion deposit remaining on the bodies of the aphids was sufficiently high to prevent emergence of the hymenopterous parasites *Aphidius testaceipes* (Cress.) and *Ephedrus nitidus* Gahan;* the parasites, in trying to emerge from the aphid hosts, received enough parathion on their mouth parts and antennæ to kill them even before they could get their heads outside the host "shells." At ninety-six hours after spraying, the parasites did emerge, but after moving about on the sprayed cherry foliage for about one hour they became moribund and soon died.

As a result of these and other field experiments on aphid-control, 15 per cent parathion wettable powder was recommended in 1950 at 1 pound per 100 gallons as a dilute spray, or 8 pounds per acre as a concentrate spray, as an alternative to nicotine sulphate-soap for the summer control of the mealy plum aphid and the woolly apple aphid. To prevent the occurrence of toxic residues on mature fruit, growers were advised to apply parathion no later than one month before harvest. It was not recommended as a summer spray for the control of the black cherry aphid because cherries are picked so early in the season that such a spray might give excessive residues at harvest.

In 1953 parathion was removed from the British Columbia pest-control calendar because of its high toxicity to man. It was replaced by another but less hazardous organic phosphate—malathion.

Malathion.—In 1952 malathion, applied by high-volume hand-gun machine or by concentrate machine, gave better aphid-control than any other aphicide then recommended in the spray calendar. In an Italian-prune orchard, with concentrate spraying, 25 per cent malathion, 16 pounds per acre, was compared with 40 per cent nicotine sulphate, 1 gallon, plus washing soda, 4 pounds, for the control of the mealy plum aphid. Three days after spraying, the average number of living aphid colonies per tree was: Malathion, 0; nicotine sulphate-washing soda, 5; check, 63. In an apple-orchard, concentrate sprays of malathion and nicotine sulphate-washing soda, at the same dosages as above, were compared for the control of the apple aphid. Three days after spraying, the average number of winged aphids per 250 leaves was: Malathion, 5; nicotine sulphate-washing soda, 42; check, 127. Control in this experiment was considerably better than the figures indicate, for the ratio of alate to apterous forms was much greater on the sprayed trees than on unsprayed trees. In an experiment on the control of the

* Determined by G. S. Walley, Entomology Division, Ottawa.

green peach aphid with high-volume spraying, no living aphids were found five days after applying 25 per cent malathion, 2 pounds per 100 gallons; a few aphids were alive on trees sprayed with 15 per cent parathion, 1 pound, or with 40 per cent nicotine sulphate, 1 pint, plus washing soda, 0.5 pound. Other experiments showed that malathion readily controlled the woolly apple aphid and the thistle aphid; it was also most effective against the black cherry aphid, but, in some instances, injured cherry foliage.

Malathion, like parathion, was much more injurious to predacious coccinellid and syrphid larvæ than nicotine sulphate. Consequently, where malathion is not required for mite-control, it is advisable to use nicotine sulphate to control light to medium aphid infestations; severe aphid infestations may require malathion.

Nicotine Sulphate plus Washing Soda. — The standard recommendation of nicotine sulphate plus soap could not be used effectively with concentrate sprayers because of excessive foaming from the soap. It was found, however, that washing soda could be used in the place of soap to liberate the nicotine. Nicotine sulphate-washing soda gave satisfactory control of orchard aphids whether it was applied by concentrate or by high-volume hand-gun machines. For example, three days after spraying a severe infestation of the mealy plum aphid on prune-trees with a concentrate machine, the average number of living aphid colonies per tree was: 40 per cent nicotine sulphate, 1 gallon, plus washing soda, 4 pounds, per acre, 5 colonies; check, 63 colonies. In another prune-orchard, lightly infested with the mealy plum aphid, no aphids were found alive four days after high-volume hand-gun spraying with 40 per cent nicotine sulphate, 1 pint, plus washing soda, 0.5 pound, per 100 gallons of spray.

As a result of these and other field experiments, nicotine sulphate-soap was replaced by nicotine sulphate-washing soda in the 1952 spray calendar.

Table III.—Effect of Polyethylene Glycol Ester of Oleic Acid on the Toxicity of Nicotine to the Mealy Plum Aphid on Italian Prune-trees

Material	Amount per Acre	Average Number of Living Aphid Colonies per Tree[1]
Nicotine alkaloid, 40% liquid[2]	1 qt.	10
Nicotine alkaloid, 40% liquid	1 qt.	10
Polyethylene glycol ester of oleic acid[3]	1 qt.	
Silicone,[4] 1 part; stove oil,[5] 2 parts	0.6 oz.	
Nicotine sulphate, 40% liquid[2]	1 qt.	13
Washing soda[6]	1 lb.	
Nicotine sulphate, 40% liquid	1 qt.	15
Nicotine sulphate, 40% liquid	1 qt.	21
Polyethylene glycol ester of oleic acid	1 qt.	
Silicone, 1 part; stove oil, 2 parts	0.6 oz.	
Check	No spray	63

[1] Based on three trees per treatment, three days after spraying.
[2] Tobacco By-products & Chemical Corporation, Louisville, Ky.
[3] Glyco Products Company, Inc., Brooklyn, N.Y.
[4] Antifoam preparation. Dow-Corning Products Division, Fiberglass Canada Limited, Toronto, Ont.
[5] Approximately 34 S.S.U. Vis. 100° F., over 75 per cent U.R. Shell Oil Company, Penticton, B.C.
[6] Sodium carbonate ($10H_2O$). Church & Dwight Company, Montreal, Que.

Nicotine plus Polyethylene Glycol Derivatives.—Wigglesworth (1945) and Turner *et al.* (1951) showed in laboratory work that certain polyethylene glycol derivatives enhanced the toxicity of nicotine. However, field experiments conducted by the Summerland entomologists in 1952 indicated that polyethylene glycol esters of oleic acid and tall oil did not measurably increase the toxicity of nicotine sulphate or nicotine alkaloid to many species of orchard aphids, whether the sprays were applied by high-volume hand-gun machine or by concentrate machine. The results of one of these experiments, with a concentrate machine, are shown in Table III.

BHC and Lindane.—In 1947 BHC was mentioned in the British Columbia spray calendar for the control of various species of orchard aphids. As Morgan (1947) proved that the toxicity of BHC was enhanced when it was used with oil, the recommendation was changed in 1948 to BHC plus distillate oil, stove oil, or summer oil. Growers were warned not to apply BHC later than one month before harvest, because this insecticide gives fruit an objectionable flavour when it is applied too close to picking-time (Proverbs 1948).

Experiments in 1947 and 1948 showed that control of the woolly apple aphid was much improved by increasing the BHC dosage from one-eighth to one-quarter of a pound of gamma isomer per 100 gallons of spray. However, the recommended dosage of one-eighth of a pound was not increased, as this would have probably resulted in tainted fruit.

Lindane, like BHC, gave better control of aphids when used with oil than when used alone. For example, 25 per cent lindane, 0.5 pound per 100 gallons of spray, was compared with an equal quantity of lindane mixed with 0.5 gallon of stove oil for the control of the woolly apple aphid. Four days after spraying, with a high-volume hand-gun machine, the average number of aphids per internode was: Lindane-stove oil, 1.7; lindane alone, 11.0; check, 350. In another orchard no living woolly apple aphids were found five days after concentrate spraying with 50 per cent lindane, 2 pounds, plus summer oil, 1 gallon, per acre; aphids were abundant on check-trees when the mortality counts were made.

Although lindane does not taint fruit as much as BHC, it has not been recommended because of its prohibitive cost.

Other Insecticides. — In 1949 and 1950 HETP gave good control of the apple aphid and the woolly apple aphid. For example, four days after high-volume hand-gun spraying with 50 per cent HETP, 1 pint per 100 gallons, the average number of woolly apple aphids per internode was 0.1, in comparison with 350.0 on unsprayed trees. HETP, however, was not recommended to growers because it injured some varieties of apple and pear, besides being quite as dangerous to handle as parathion.

Forty per cent Pyrolan,* 2 quarts per acre, or Endrin,† 18.5 per cent, 1 quart, or Isodrin,‡ 18.5 per cent, 1 quart, applied by concentrate machine, gave good initial mortality of the woolly apple aphid in a McIntosh-apple orchard. Six weeks later many aphids were present on the trees sprayed with these materials, whereas no living aphids were found on trees sprayed with 50 per cent malathion, 6 pounds per acre. In another experiment, where the dosage of Pyrolan, on an acreage basis, was approximately doubled, very good control of the mealy plum aphid was obtained on apricot-trees with a high-volume hand-gun sprayer. In view of the variable results with Pyrolan, it should be further tested as an aphicide.

In 1952 a concentrate spray of Pyrenone T-503§ at 1 gallon per acre did not give satisfactory control of the apple

* Emulsifiable liquid. 1-phenyl-3-methyl-pyrazolyl-(15)-dimethyl carbamate. Geigy Co. Inc., Bayonne, N.J.

† Emulsifiable liquid. Hexachlor-epoxy-octahydro-endo-endo-dimethano naphthalene. Shell Chemical Corporation, Julius Hyman Division, Denver, Colo.

‡ Emulsifiable liquid. Hexachloro-hexahydro-endo-endo-dimethano naphthalene. Shell Chemical Corporation, Julius Hyman Division, Denver, Colo.

§ Emulsifiable liquid. Pyrethrins 0.4 per cent w/v, rotenone 2 per cent w/v, piperonyl cyclonene 4 per cent w/v. U.S. Industrial Chemicals, Baltimore, Md.

aphid on Stayman apple-trees. Results with this material varied when it was used to control the mealy plum aphid. In an Italian-prune orchard, where the spray was applied by concentrate machine at the same dosage as above, the average number of living aphid colonies per tree three days after spraying was: Pyrenone, 5; check, 63. However, in an apricot-orchard that was sprayed with a high-volume hand-gun machine, Pyrenone, 1 pint per 100 gallons (approximately 1 gallon per acre), eliminated only 6 per cent of the aphid colonies. Differences in control in the last two experiments might be due, in part, to the methods of spraying.

The systemic insecticide Isopestox* gave very good control of the woolly apple aphid on McIntosh apple-trees when applied a few weeks before harvest by concentrate machine at 6 pounds of technical crystals per acre. Experiments with this insecticide were discontinued when it was learned that it was very much more injurious to man than was at first believed.

* Bis(isopropylamino)fluorophosphine oxide. Pest Control Ltd., Bourn, Cambridge, England.

Another systemic insecticide, schradan, applied by concentrate sprayer at 1 gallon of 63.3 per cent emulsifiable liquid per acre, did not give satisfactory control of the apple aphid in a mixed planting of Delicious and McIntosh apple-trees. Ripper *et al.* (1950) have pointed out that schradan has very little value as a contact insecticide, almost all of its potency being due to its systemic properties. Consequently, if the insecticide is improperly absorbed by the plant, as is often the case with mature plants, sap-sucking insects may not receive a lethal dose. This might account for the poor results in the foregoing experiment, for the insecticide was applied late in the season (August 14), when apple-trees were no longer growing rapidly.

Dormant Sprays versus Petal-fall Sprays

British Columbia growers sometimes find it very difficult to apply dormant sprays on time because, in early spring, water for spraying is not readily available, orchards are often muddy, and there is

Table IV.—Numbers of Colonies of the Black Cherry Aphid on Bing and Lambert Cherry-trees after a Dormant or Petal-fall Spray of Various Insecticides

Material	Amount per 100 Gal.	Stage and Time of Application	Colonies per Six Trees on May 18
Parathion, 15% wettable powder[1]	0.75 lb.	Dormant, Mar. 22	0
Dormant oil[2]	2.0 gal.		
Soya-flour[3]	0.5 lb.		
Parathion, 15% wettable powder	0.75 lb.	Dormant, Mar. 22	1
Parathion, 15% wettable powder	0.75 lb.	95% petal-fall, May 3	2
DNOC, 40% wettable powder[4]	1.5 lb.	Dormant, Mar. 22	3
Dormant oil	2.0 gal.		
Soya-flour	0.5 lb.		
Nicotine sulphate, 40% liquid[5]	0.75 pt.	95% petal-fall, May 3	14
Soap[6]	3.0 lb.		
Check	No spray		37

1 Pennsylvania Salt Manufacturing Company, Tacoma, Wash.
2 Approximately 220 S.S.U. Vis. 100° F., 65 per cent U.R. Shell Oil Company, Penticton, B.C.
3 Sprasoy. Glidden Paint Company, Chicago, Ill.
4 2-methyl-4,6-dinitrophenol. Dow Chemical Company, Midland, Mich.
5 The N. M. Bartlett Spray Works, Beamsville, Ont.
6 Rinso. Lever Bros., Montreal, Que.

almost continuous wind. In 1949 an experiment was conducted to determine whether a petal-fall application was satisfactory as an alternative to the dormant spray for the control of the black cherry aphid. Dormant sprays of parathion, alone and with dormant oil, and DNOC-dormant oil were compared with petal-fall sprays of parathion and nicotine sulphate.

Table IV shows that the petal-fall application of parathion, which was timed to kill the aphids before the stem mothers had started to reproduce, gave just as good control as the dormant sprays, directed against the overwintering eggs. The petal-fall spray of parathion and the dormant sprays of parathion, parathion-dormant oil, and DNOC-dormant oil held the aphid populations at low levels for the remainder of the growing season, whereas in the nicotine sulphate plot the trees were severely infested with aphids at harvest-time.

As a result of this and similar experiments, parathion was recommended, in 1950 and 1951, at petal-fall as an alternative to the dormant spray of DNOC (or DNOCHP) plus dormant oil for the control of the black cherry aphid.

Summary

Field experiments from 1947 to 1953 on the chemical control of aphids in British Columbia orchards gave the following results:—

1. Malathion was very effective against orchard aphids, and, in 1953, was recommended as an alternative to nicotine sulphate-washing soda for the summer control of all species except the black cherry aphid.

2. The black cherry aphid was controlled just as effectively with a petal-fall spray of parathion as with DNOC-dormant oil applied at the dormant stage of cherry-bud development.

3. During summer, parathion gave better control of the mealy plum aphid and the woolly apple aphid than nicotine sulphate-soap. From 1950 to 1952 it was recommended as an alternative to nicotine for the control of these species.

4. BHC-dormant oil and parathion-dormant oil, applied at the dormant stage of bud development, gave just as high mortality of the overwintering eggs of the mealy plum aphid, the thistle aphid, and the black cherry aphid as the usual treatment of DNOC (or DNOCHP)-dormant oil.

5. The toxicity of lindane was increased when the insecticide was used with oil. Although lindane does not taint the flavour of fruit as much as BHC, it was not recommended because of its prohibitive cost.

6. The systemic insecticide Isopestox was very effective against the woolly apple aphid. Schradan, another systemic insecticide, did not give satisfactory control of the apple aphid when applied about one month before harvest.

7. Polyethylene glycol esters of tall oil and oleic acid did not measurably enhance the aphicidal value of nicotine sulphate or nicotine alkaloid.

8. HETP gave good control of the apple aphid and the woolly apple aphid, but was not recommended because it injured some varieties of apple and pear.

Acknowledgments

J. Marshall, Officer in Charge, Entomology Laboratory, Summerland, directed the investigations on the control of the apple aphid and the woolly apple aphid.

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BOOK REVIEW

The Beetles of the Pacific Northwest, Part I: Introduction and Adephaga. By Melville H. Hatch. Univ. Wash. Publications in Biology, Vol. 16, pp. 1–340. Sept., 1953. Univ. Wash. Press, Seattle 5, $5.

In this volume of 340 pages Professor Hatch has compiled an exhaustive survey of the beetles of Washington, Idaho, Oregon, and British Columbia—through "Adephaga." To students and collectors in these areas the book is invaluable, and to the continent at large there will be many surprises: so many unexpected species have turned up, and the supposed range of several rarities have been greatly extended.

The book opens with an inspiring introduction, followed by a history of what has gone before—the literature, the collectors, and their collections. There are able discussions on the structure of coleoptera, geographical factors. Within the covers we find a list of introduced species, with a first available record for each. There is an ample bibliography, and an index system that is as perfect as may be conceived. There are thirty-seven plates that are pleasing to look at and of real help in identifying our species.

In the text itself each group is preceded by a key, then the species described in more detail, with indications of range, etc. New species are described on the spot, thus pointing their positions. An important innovation is a complete bibliography of Northwestern references under each species.

To some it may be disconcerting that the placid system of classification we have been used to is somewhat disrupted: species are not where we expect to find them. Some of the synonyms may be disputed and some good species may have been relegated to lesser ranks. But (if the but exists) the book is packed with important information, and the amount of work and research that has gone into the making is beyond measure. We sense at once that the author is deeply interested in his subject, and he has presented his findings sincerely and without bias. The completeness of his system, perhaps foreshadowed by Blatchley, may well set a pattern for other States and Provinces to follow.

G. Stace Smith.

CHEMICAL CONTROL OF THE PEACH TWIG BORER, *ANARSIA LINEATELLA* ZELL. (LEPIDOPTERA: GELECHIIDÆ), IN THE OKANAGAN VALLEY OF BRITISH COLUMBIA.*

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In the Okanagan Valley of British Columbia the peach twig borer, *Anarsia lineatella* Zell., has two complete generations per year. It overwinters as an immature larva in an excavation in the bark, usually in a crotch between 1- and 2-year-old wood. The larvæ leave their winter quarters at the balloon stage of peach flower-bud development. The overwintered larvæ, which in this paper are considered the first-generation larvæ, feed entirely in the twigs, but the second-generation larvæ feed also on the fruit.

Most fruit-growers in the Interior of British Columbia spray their peach and apricot trees every year for the control of the peach twig borer. Control measures are usually aimed against the first-generation larvæ. Lime-sulphur and sometimes lead arsenate were used for many years. Unfortunately, lime-sulphur sometimes injures apricot-trees, and lead arsenate is phytotoxic to both peach and apricot trees.

In 1947, 1948, and 1952 a number of new insecticides were tried for the control of the peach twig borer. Some of these were mixed with petroleum oil and applied at the delayed dormant stage of tree development to kill the larvæ in their winter quarters; others were applied, without oil, at the balloon-bud, petal-fall, or fall-of-husk stage to destroy the first-generation larvæ feeding on the twigs.

Materials and Methods

Delayed Dormant Sprays versus a Fall-of-husk Spray.—In 1947, distillate oil-BHC, dormant oil-DNOC, and dormant oil-lime-sulphur were applied to apricot-trees at the delayed dormant stage and to peach-trees at the dormant stage. At the fall-of-husk stage, DDT was applied to about twenty of the untreated apricot-trees. The sprays were all applied with a high-volume hand-gun machine. On May 20, counts were made of the number of apricot twigs injured per six trees by the first-generation larvæ of the peach twig borer (Table I).

Delayed Dormant Sprays versus Balloon-bud Sprays.—In 1948, distillate oil-BHC, dormant oil-BHC, and dormant oil-lime-sulphur were applied to peach-trees at the delayed dormant stage with a high-volume hand-gun machine. An intermediate solvent (Velsicol AR-50) was added to the oil-BHC formulations to ensure rapid solution of the BHC. DDT and lime-sulphur were applied to a number of the untreated trees at the balloon stage of flower-bud development with a concentrate machine. Twelve days after application of the oil sprays, overwintered larvæ of the borer were cut out from the bark of sprayed and unsprayed trees to determine what percentage of them had been killed by the sprays. Fruits were examined, at harvest, to determine how many of them had been injured by the second-generation larvæ (Table II).

In another peach-orchard, the oil-BHC and oil-lime-sulphur sprays were applied at the delayed dormant stage, and lime-sulphur, DDT, and parathion at the balloon-bud stage. DDT and parathion were applied with a concentrate sprayer, and the other chemicals with a high-volume hand-gun machine. Fruits were examined at harvest, as in the previous experiment, to determine how many of them had been injured by the second-generation larvæ (Table III).

Various Sprays Applied at the Delayed Dormant Stage. — In a third peach-orchard, distillate oil-BHC, dormant oil-BHC, dormant oil-lime-sulphur, parathion, and DDT were applied at the

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delayed dormant stage with a high-volume hand-gun machine. Eleven weeks later, counts were made of the number of twigs injured by the first-generation larvæ, and, at harvest, fruits were examined to determine how many of them had been injured by the second-generation larvæ (Table IV).

Balloon-bud Spray of DDT. — In 1948, DDT, 50 per cent wettable powder at 2 pounds per 100 gallons, was applied with a high-volume hand-gun machine to about fifty apricot-trees at the late balloon-bud stage. One month later, sprayed and unsprayed trees were examined to determine the number of twigs injured by the first-generation larvæ, and, at harvest, fruits were examined to determine how many of them had been injured by the second-generation larvæ.

Balloon-bud Sprays versus a Petal-fall Spray. — In 1952 a balloon-bud spray of DDT was compared with a 90-per-cent petal-fall spray of DDT in a mixed planting of Veteran and Vedette peach-trees. Lime-sulphur and Systox (diethoxythiophosphoric acid ester of 2-ethyl mercapto-ethanol) were also applied at the balloon-bud stage. All the sprays were applied to duplicate plots with a concentrate machine. On May 26, records were made of the number of twigs injured by the first-generation larvæ, and, at harvest, fruits were examined to determine how many of them had been injured by the second-generation larvæ (Table V).

Results and Discussion

Of all the sprays tested, DDT as a balloon-bud or petal-fall spray gave best control of the peach twig borer, being consistently more effective than the recommended treatment of lime-sulphur (Tables II to V). Table V shows that the first-generation larvæ injured twice as many twigs when DDT was applied at petal-fall as when applied at the balloon-bud stage, but the percentages of fruit injured by the second-generation larvae were approximately equal. Differences in twig injury are attributed to the larvæ having attacked some of the twigs before DDT was applied at petal-fall. The success of the petal-fall spray depends on the larval habit of feeding on several twigs. These results suggest that nurseries and young non-bearing orchards should be sprayed at the balloon-bud stage to control the borer before it can enter the twigs and spoil the shape of the tree; in bearing orchards, the petal-fall spray would be more economical, as it also controls *Lygus* bugs.

Where *Lygus* bugs are not a problem in bearing orchards, a number of growers are applying 10 per cent lime-sulphur early in the balloon stage of flower-bud development. This treatment has given satisfactory results against both peach leaf curl and the borer, although the dormant application is the one normally recommended for controlling the leaf curl disease.

On the basis of the number of injured twigs, DDT applied at the fall-of-husk stage had no effect on the borer (Table I). However, this was not necessarily so, for, when the spray was applied, most of the injured twigs were already tunnelled by larvæ. Unfortunately, the over-all effect of the spray could not be estimated at harvest from fruit injured by second-generation larvæ, as in all the plots, including the check, such injury was negligible.

A delayed dormant spray of dormant oil-lime-sulphur gave rather good control of the borer in three experiments (Tables I, II, and IV), but was unsatisfactory in a fourth (Table III). Poor control in the latter can be partly attributed to the exceptionally high borer population in that part of the orchard sprayed with oils. The degree of effectiveness of dormant oil-lime-sulphur was remarkable. Since this mixture controlled peach leaf curl, and is effective against the San Jose scale, *Aspidiotus perniciosus* Comst., it would be most useful if peach-trees in British Columbia were not susceptible to oil injury. Table II shows that larval mortality in the winter quarters was lower in the

Table I.—Injuries Caused to Apricot-trees by First-generation Larvæ of the Peach Twig Borer after Various Delayed Dormant and Fall-of-husk Sprays, 1947

Material	Amount per 100 Gal.	Stage and Time of Application	Twigs Injured per Six Trees
Distillate oil[1]	2 gal.	Delayed dormant, Mar. 12	8
BHC wettable powder[2]	0.24 lb.		
6% gamma isomer	Gamma isomer 1 lb.		
Soya-flour[3]			
Dormant oil[4]	1 gal.	Delayed dormant, Mar. 12	11
Lime-sulphur[5]	3 gal.		
Soya-flour	1 lb.		
Dormant oil	2 gal.	Delayed dormant, Mar. 12	16
DNOC, 50% wettable powder[6]	1.5 lb.		
Soya-flour	1 lb.		
DDT, 50% wettable powder[7]	2 lb.	Fall-of-husk, Apr. 25	101
Check	No spray	———	71

[1] 42 S.S.U. Vis. 100° F., 77 per cent U.R. Imperial Oil Company, Sarnia, Ont.
[2] Imperial Chemical Industries, England.
[3] Glidden Paint Company, Chicago, Ill.
[4] Approximately 220 S.S.U. Vis. 100° F., 65 per cent U.R. Imperial Oil Company, Ioco, B.C.
[5] Specific gravity 1.28. Oliver Chemical Company, Penticton, B.C.
[6] 2-methyl-4,6-dinitrophenol. Niagara Sprayer & Chemical Division, Food Machinery Corporation, Middleport, N.Y.
[7] The Sherwin-Williams Co. (Green Cross Insecticides), Montreal, Que.

dormant oil-lime-sulphur plot than in the oil-BHC plots, but the percentages of injured fruit were approximately equal. This suggests that lime-sulphur was still toxic when the larvæ emerged from hibernation.

Delayed dormant sprays of distillate oil-BHC and dormant oil-BHC gave satisfactory control of the borer in three orchards (Tables I, II, and IV), but were unsatisfactory in a fourth (Table III). It was in the fourth orchard that dormant oil-lime-sulphur gave poor control, and, again, failure can be partly attributed to the exceptionally high borer population initially present in that part of the orchard. According to Venables,* oil sprays are ineffective against the borer when the larvæ are in their winter quarters. Examination of hibernaculæ twelve days after application of a delayed dormant spray showed, however, that oil-BHC killed a large number of larvæ (Table II). If Venables's finding is correct, the oil simply acted as a penetrant and carrier for the toxicant. Though oil-BHC was rather effective in killing the overwintering larvæ, it has not been recommended in view of the excellent results from DDT applied as a dual-purpose treatment for the borer and *Lygus* bugs later in the season.

The mixture of dormant oil-DNOC-soyaflour gave satisfactory control of the borer (Table I), but could not be recommended because it caused bud injury to apricot-trees. Without soya-flour emulsifier, the spray was even more injurious to dormant peach-trees.

One experiment indicated that a balloon-bud spray of parathion gave good control of the borer (Table III), but because of the very light crop in that instance the results are not conclusive. Parathion applied at the delayed dormant stage appeared to be very effective when judged by the number of twigs injured by first-generation larvæ, but it was much less effective when judged by the percentage

* Venables, E. P. The peach twig borer or peach worm. Canada Dept. Agr., Entomological Laboratory, Vernon, B.C., mimeographed circular. 1940.

Table II.—Mortalities of Overwintering Larvæ of the Peach Twig Borer, and Injuries Caused to Peach Fruit by the Second-generation Larvæ, after Various Delayed Dormant and Balloon-bud Sprays, 1948.

Material	Amount per 100 Gal. (or per Acre)	Stage and Time of Application	Larvæ Killed in Winter Quarters[1]	Fruit Injured[2]
			Per Cent	Per Cent
Distillate oil[3]	1 gal.	Delayed dormant, Apr. 2	87.5	1.8
Velsicol AR-50[4]	1 pt.			
BHC wettable powder[5]	0.25 lb.			
10% gamma isomer	Gamma isomer			
Soya-flour	1 lb.			
Dormant oil	1 gal.	Delayed dormant, Apr. 2	92.6	1.3
Velsicol AR-50	1 pt.			
BHC wettable powder	0.25 lb.			
10% gamma isomer	Gamma isomer			
Soya-flour	1 lb.			
Dormant oil	1 gal.	Delayed dormant, Apr. 2	45.5	1.1
Lime-sulphur	3 gal.			
Soya-flour	1 lb.			
Lime-sulphur	20 gal. (per acre)	Early balloon, Apr. 21	------	0.6
DDT, 50% wettable powder	16 lb. (per acre)	Early balloon, Apr. 21	------	0.0
Check	No spray	------	0.0	9.6

1 Based on twenty-five larvæ per plot.
2 Based on approximately 2,000 fruits taken at random from twenty trees in each plot.
3 38 S.S.U. Vis. 100° F., 75 per cent U.R. Shell Oil Company, Penticton, B.C.
4 A methylated naphthalene. Velsicol Corporation, Chicago, Ill.
5 Pennsylvania Salt Manufacturing Company, Tacoma, Wash.

of fruit injured by second-generation larvæ (Table IV). The high percentage of injured fruit in this instance was probably due to reinfestation by moths flying in from adjacent unsprayed trees. Experiments were discontinued with this promising insecticide when it was removed from the pest-control calendar because of its high toxicity to man.

The balloon-bud spray of Systox evidently gave satisfactory control of the borer (Table V), but this insecticide should be further investigated, for, generally speaking, Systox is not very effective against mandibulate insects.

In the experiment on the control of the borer on apricot-trees with a balloon-bud spray of DDT, examination of twenty of the trees, one month after spraying, showed that the first-generation larvæ had injured an average of 0.7 twigs per tree. Ten unsprayed trees showed an average injury of 7.7 twigs per tree. At harvest, however, no fruit was found injured by second-generation larvæ. Such results are not at all uncommon concerning the peach twig borer. Sometimes the hymenopterous parasite *Paralitomastix pyralidis* Ashm.* greatly influences the results. In 1948, 48 per cent of the second-generation larvæ were killed by this parasite in a Penticton orchard. A small percentage of injured fruit at harvest does not always mean that the borer population has been reduced. If the trees are growing rapidly, with an abundance of succulent terminal growth, most of the second-generation larvæ continue to feed in the twigs rather than attack ripening fruit. It is impractical to record the number of twigs injured by second-generation larvæ because of the density of mature foliage at harvest. Con-

* Determined by Dr. O. Peck, Entomology Division, Ottawa.

Table III.—Injuries Caused to Peach Fruit by the Second-generation Larvæ of the Peach Twig Borer after Various Delayed Dormant and Balloon-bud Sprays, 1948

Material	Amount per 100 Gal. (or per Acre)	Stage and Time of Application	Fruit Injured[1]
			Per Cent
Distillate oil[2]	1 gal.	Delayed dormant, Apr. 1	6.1
Velsicol AR-50	1 pt.		
BHC wettable powder	0.25 lb.		
10% gamma isomer	Gamma isomer		
Soya-flour	1 lb.		
Dormant oil	1 gal.	Delayed dormant, Apr. 1	4.7
Velsicol AR-50	1 pt.		
BHC wettable powder	0.25 lb.		
10% gamma isomer	Gamma isomer		
Soya-flour	1 lb.		
Dormant oil	1 gal.	Delayed dormant, Apr. 1	6.4
Lime-sulphur	3 gal.		
Soya-flour	1 lb.		
Lime-sulphur	10 gal.	Late balloon, Apr. 23	1.5
Parathion, 15% wettable powder[3]	7.5 lb. (per acre)	Late balloon, Apr. 23	0.6
DDT, 50% wettable powder	16 lb. (per acre)	Late balloon, Apr. 23	0.4
Check	No spray		11.2

[1] Based on approximately 1,500 fruits taken at random from fifteen trees in each plot, with exception of parathion plot, where only 180 were examined.
[2] 38 S.S.U. Vis. 100° F., 75 per cent U.R. Shell Oil Company, Penticton, B.C.
[3] American Cyanamid Company, New York, N.Y.

Table IV.—Injuries Caused to Peach-trees by the First-generation Larvæ of the Peach Twig Borer, and Injuries Caused to the Fruit by Second-generation Larvæ, after Various Delayed Dormant Sprays, 1948.

Material	Amount per 100 Gal.	Twigs Injured per 12 Trees	Fruit Injured[1]
			Per Cent
Distillate oil[2]	1 gal.	11	1.6
Velsicol AR-50	1 pt.		
BHC wettable powder	0.25 lb.		
10% gamma isomer	Gamma isomer		
Soya-flour	1 lb.		
Dormant oil	1 gal.	8	1.0
Velsicol AR-50	1 pt.		
BHC wettable powder	0.25 lb.		
10% gamma isomer	Gamma isomer		
Soya-flour	1 lb.		
Dormant oil	1 gal.	5	1.4
Lime-sulphur	3 gal.		
Soya-flour	1 lb.		
Parathion, 15% wettable powder	1 lb.	5	4.2
DDT, 50% wettable powder	6 lb.	7	0.6
Check	No spray	275	7.3

[1] Based on approximately 2,500 fruits taken at random from fifteen trees in each plot.
[2] 38 S.S.U. Vis. 100° F., 75 per cent U.R. Shell Oil Company, Penticton, B.C.

sequently, the most reliable method of estimating control is by counting the number of twigs injured by the first-generation larvæ. When the twigs are injured by other agents, such as peach leaf curl, it is usually impractical to separate the two types of twig injury; then it becomes necessary to use the percentage of fruit injured by second-generation larvæ as an estimate of control.

The use of DDT for the control of the peach twig borer in British Columbia orchards may not be so suspect as originally thought. Phytophagous mites have not increased to any noticeable degree on peach or apricot trees sprayed with DDT. Furthermore, the balloon-bud and petal-fall sprays of DDT probably do not affect the adults of *P. pyralidis,* because this parasite does not emerge from the mature borer larva until about one month after petal-fall of peaches.

Summary

Balloon-bud or petal-fall sprays of DDT gave better control of the peach twig borer in British Columbia peach and apricot orchards than the usual balloon-bud spray of lime-sulphur, and did not cause any noticeable increase in numbers of phytophagous mites. Delayed dormant sprays of dormant oil-BHC, distillate oil-BHC, and dormant oil-lime-sulphur gave rather good control in three out of four orchards, but were not so effective as a balloon-bud spray of lime-sulphur. The oil-BHC sprays killed most of the larvæ before they emerged from hibernation, whereas the oil-lime-sulphur killed many larvæ after they emerged from hibernation. BHC was presumably largely responsible for the lethal effect of the oil-BHC mixtures, the oil acting mainly as a vehicle to bring the BHC into contact with the hibernaculæ. A delayed dormant spray of dormant oil-DNOC-soyaflour gave satisfactory control, but it injured apricot buds; without soya-flour emulsifier, the spray was very injurious to dormant peach-trees. Limited evidence indicated that a balloon-bud spray of parathion was most effective in controlling the borer. A balloon-bud spray of Systox was not quite so effective as a balloon-bud spray of lime-sulphur.

Table V.—Injuries Caused to Peach-trees by the First-generation Larvæ of the Peach Twig Borer, and to the Fruit by Second-generation Larvæ, in Duplicate Plots after Various Balloon-bud and Petal-fall Sprays, 1952.

Material	Amount per Acre	Stage and Time of Application	Twigs Injured per Tree[1] Average	Fruit Injured[2]
				Per Cent
DDT, 50% wettable powder	16 lb.	Late balloon, Apr. 24	7.1	0.0
DDT, 50% wettable powder	16 lb.	90% petal-fall, May 12	15.1	0.1
Lime-sulphur	20 gal.	Late balloon, Apr. 24	10.1	0.5
Systox, 42.4% emulsifiable liquid[3]	0.25 gal.	Late balloon, Apr. 24	17.9	1.3
Check	No spray		35.7	16.7

[1] Based on approximately ten trees per plot, except that the single check plot was based on fifteen. Figures include twigs injured by the previous severe winter.

[2] Based on 1,000 fruits per plot, except that the single check plot was based on 180.

[3] Diethoxythiophosphoric acid ester of 2-ethyl mercapto-ethanol. Geary Chemical Corporation, New York, N.Y.

NOMENCLATORIAL NOTES ON PLECOPTERA

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Since publication of my last stonefly paper, additional studies have indicated the new synonymies and placements described below.

Capnia labradora n. sp.

1944. *Capnia columbiana* Ricker (in part), Canadian Ent. 76, p. 178. (Figs. 4, 7, and 11 illustrate the new species *labradora*.)

Holotype ♂ and paratype ♂: Nain, Labrador, July 2, Waugh. (Holotype in the Canadian National Collection, paratype in the author's collection.)

The two specimens above were described and illustrated in the 1944 paper. Their rather close resemblance to the western species *columbiana* suggested caution in proposing a new name, but additional western material shows that it does not vary toward the eastern type. The supra-anal processes of the two species are compared in Figs. 11 and 12 of the 1944 paper; in *columbiana* the tips are more divergent, and the hind border is wavy.

Capnia nearctica Banks

1918. *Capnia nearctica* Banks, Rep. Can. Arctic Exped.; 3(B), p. 3.

1938. *Capnia hantzschi* Ricker, Can. Ent. 70, p. 173. *New synonymy.*

1944. *Capnia nearctica* Ricker, Can. Ent. 76, p. 178.

Study of a paratype of *nearctica* at the Museum of Comparative Zoology, now mounted in balsam, shows that it agrees completely with the descriptions of *hantzschi* given by me in 1938 and 1944. The holotype of *nearctica* is supposed to be at Ottawa, but apparently cannot be found there; however, all of the type series were from the one locality.

Nemoura (Podmosta) decepta Frison

1942. *Nemoura decepta* Frison, Pan-Pac. Ent., 18, p. 13. Description of ♂.

1943. *Nemoura decepta* Ricker, Indiana Univ. Pub., Sci. Ser. 12, p. 69. Description of ♀ from teneral specimens.

1952. *Nemoura rossi* Ricker, Indiana Univ. Pub., Sci. Ser. 18, p. 45. Description of ♀. *New synonymy.*

Collections of *decepta* containing mature individuals of both sexes have now been received from Mr. R. A. Hays and Mr. S. G. Jewett, Jr. They indicate that the females described as *rossi* belong with *decepta*. My 1943 illustration (Fig. 37) of the female is inadequate. More extensive dusky pigment along the cord of the wing distinguishes fully-hardened specimens of this species from *delicatula*, but this difference is better shown in the female than in the male.

Leuctra (Despaxia) augusta Banks

1907. *Leuctra augustus* Banks, Can. Ent. 39, p. 330. Description of ♀.

1923. *Leuctra glabra* Claassen, Can. Ent. 55, p. 261. Description of ♂. *New synonymy.*

1925. *Leuctra augusta* Needham and Claassen, Monogr. Plecop., p. 224. (The female illustrated was evidently drawn from the type, but is very misleading.)

1925. *Leuctra glabra* Needham and Claassen, Monogr. Plecop., p. 228.

1929. *Leuctra glabra* Neave, Contr. Can. Biol. Fish. 4, p. 162. Description of ♀.

1952. *Leuctra glabra* Ricker, Indiana Univ. Pub., Sci. Ser. 13, p. 78. New illustrations of ♀.

There are two cotypes of *augusta* in the MCZ (not just one, as stated in 1952), and one of them is complete. The reduction of abdominal sclerotization and the form of the subgenital plate are as in *glabra*.

Leuctra (Paraleuctra) occidentalis Banks

1907. *Leuctra occidentalis* Banks, Can. Ent. 39, p. 239. The type series includes specimens of *occidentalis, purcellana* Neave, and *forcipata* Frison.

1923. *Leuctra bradleyi* Claassen, Can. Ent. 55, p. 257. *New synonymy.*

1925. *Leuctra bradleyi* Needham and Claassen, Monogr. Plecop., p. 225; also later authors.

1942. *Leuctra projecta* Frison, Bull. Illinois Nat. Hist. Surv. 22, p. 260. *New synonymy.*

1952. *Leuctra occidentalis* Ricker (in part), Indiana Univ. Pub., Sci. Ser. 18, p. 172. Designated ♀ specimen No. 11370 in the MCZ as lectotype (but identified it wrongly).

1952. *Leuctra augusta* Ricker, *ibid.*, p. 172. (Not *augustus* Banks, 1907.)

The selection of the MCZ ♀ in 1952 as lectotype was made " to conserve current usage," in the belief that the specimen was the same as the *occidentalis* of Needham and Claassen and later authors. Unfortunately, new study of this type specimen shows that conservation of present usage is impossible, since its subgenital plate is characteristic of *bradleyi* Claassen rather than *occidentalis* auctores.

The species *occidentalis* (*bradleyi*) is quite variable in respect to the size and shape of the subterminal spine of the male cercus. The holotype of Frison's projecta has it truncated, although the paratype illustrated by him is slender and more typical. Even greater variation than shown by Frison occurs between different streams within a restricted area, and there seems no basis for the recognition of *projecta*.

Leuctra (Paraleuctra) sara Claassen

1925. *Leuctra occidentalis* Needham and Claassen, Monogr. Plecop., p. 231; and most subsequent authors. (Not *occidentalis* Banks, 1907.)

1937. *Leuctra sara* Claassen, J. Kansas Ent. Soc. 10(2), p. 44.

1952. *Leuctra occidentalis* Ricker (in part), Indiana Univ. Pub., Sci. Ser. 18, p. 122. (All records except the lectotype are *sara*.)

Authors generally since 1925 have followed Needham and Claassen in their erroneous application of the name *occidentalis* to this commonest western species of *Paraleuctra*. Claassen's *sara*, described from New York and widespread in the East, cannot be distinguished from the western form, although there is much variation in the cerci of both (cf. Frison, 1942, Bull. Illinois Nat. Hist. Survey, 22, p. 259).

The four species to be recognized in *Paraleuctra* are *forcipata* Frison, *occidentalis* Banks, *purcellana* Neave, and *sara* Claassen.

The synonymy of western *Leuctra* is summarized below:—

augusta Banks (*glabra* Claassen and *auct.*)

forcipata Frison

infuscata Claassen

occidentalis Banks (*bradleyi* Claassen and *auct.*; *projecta* Frison; *augusta* Ricker 1952, not Banks)

purcellana Neave (*bilobata* Claassen).

sara Claassen (*occidentalis auct.*, not Banks).

Isoperla petersoni Needham and Christenson

1927. *Isoperla petersoni* Needham and Christenson, Utah Agr. Exp. Sta. Bull. 201, p. 19. (This publication contains the first mention of this name, and illustrations of both nymph and adult of the insect it applies to, which must be regarded as "indications" in the sense of the International Rules. The name has subsequently been ascribed to both "Claassen" and "Needham.")

1929. *Isoperla fontium* Neave, Contr. Canadian Biol. Fish., 4, p. 161. *New synonymy.*

1931. *Isoperla petersoni* Claassen, Plecop. Nymphs N. Am., p. 74. Description of nymph.

1937. *Isoperla petersoni* Needham; in Claassen, Can. Ent. 69, p. 81: Description of ♂ ♀.

The penial sclerite and body markings of *fontium* agree with *petersoni*. The short wings of the type series of *petersoni* are exceptional but not unique; they apparently mark an isolated southern population of this species, which is abundant in the Canadian cordillera. However, similar short-winged populations of other stoneflies do not receive taxonomic recognition, and intergradations are common.

Alloperla severa (Hagen)

1861. *Perla severa* Hagen, Syn. Neur. N. Amer., p. 30. Island of Unga, Russian America.

1937. *Alloperla elevata* Frison, Trans. Amer. Ent. Soc. 61, p. 335. *New synonymy.*

1952. *Alloperla thalia* Ricker, Indiana Univ. Pub., Sci. Ser. 18, p. 178. *New synonymy.*

The absence of dark markings on the meso- and meta-thorax of the holotype of *severa* mark it as one of the typical subgenus of *Alloperla*. The "narrow brown stripe" on the pronotum, noted by Hagen, is evidently not epidermal pigment but discoloration from below, in drying. The abdomen of the specimen is missing, but its fairly large size (13 mm. to wing tips) identifies it with *elevata* Frison, which is very common along the Pacific Coast of North America and has been taken west to the Matanuska Valley of Alaska. Other western *Alloperlæ* (s.s.) are smaller, and also much scarcer.

The species *thalia* was described from two Montana males in which the supra-anal process was straight-sided, rather than dumbell-shaped, as is typical in *elevata*. However, additional material from the type locality shows that straight and dumbell shapes intergrade, and even coastal specimens vary somewhat in this respect. The female subgenital plate, described as rounded in *thalia* and subacute in *elevata*, also varies between these forms within single populations. Thus the Montana specimens are evidently an Interior form of *severa* (*elevata*), rather smaller than the Coast form and possibly differing in other average characters, but scarcely worth taxonomic recognition.

Calineuria new subgenus

This is proposed as a subgenus of *Acroneuria* Pictet, with type species *A. californica* Banks. The other known species is *A. theodora* Needham and Claassen. It is distinguished by the elongate-rectangular (rather than transversely-oval) hammer on the ninth sternite, and by the presence of a fairly complete transverse row of spinules across the occiput of the nymph, which, however, is not completely regular and is interrupted at the midline. Subanal gill tufts are absent. Both species are from the cordillera.

Attaneuria new subgenus

Another subgenus of *Acroneuria*, this is proposed for the single Eastern American species *A. ruralis* Hagen. It is characterized by a complete, though somewhat wavy, row of transverse spinules across the occiput of the nymph, a transversely-oval hammer on the ninth sternite of the male, and absence of subanal gill tufts. *Acroneuria* nymphs other than *Calineuria*, *Attaneuria*, and *Hesperoperla* all lack the transverse row of spinules on the occiput, though they have a few scattered bristles near the eyes.

ANNOTATED LIST OF FOREST INSECTS OF BRITISH COLUMBIA PART I—LASIOCAMPIDÆ, SATURNIIDÆ, LIPARIDÆ*

D. A. ROSS† AND D. EVANS‡

Introduction

This is the first of a series of annotated lists of insects collected or reared by personnel of the Forest Insect Survey in British Columbia since 1937. For the most part, the insect species to be considered are feeders on forest trees, although insects of shrub-sized *Alnus* spp., *Salix* spp., and *Prunus* spp., etc., are also included. Families or genera of insects for which our data are most complete will be treated first.

Precise collection localities are noted only where there are less than five scattered locality records for a given species; otherwise, broad distribution categories are used. Categories employed herein are as follows: Vancouver Island; Coast (west of the Coast Mountain Range); Interior British Columbia (east of the Coast Range); Southern, Northern, and Central British Columbia. For convenience, "Southern B.C." refers to that section of the Province south of 52° latitude, exclusive of Vancouver Island; "Northern" refers to the area north of 57° latitude; and "Central B.C." is that portion between. Little survey work has been done in Northern B.C.; when the term "Northern B.C." is used, it refers to areas close to the Alaska Highway.

Brief descriptions, generally of full-grown larvæ, are included in the annotated list where such stages are known to one or both of the writers. The descriptions are by no means complete but in most cases should be adequate for specific determination.

Lasiocampidæ

The caterpillars of this family are leaf-eaters. Species in the genus *Malacosoma*, the tent caterpillars, frequently are spectacular defoliators, denuding the trees or shrubs over extensive areas. Common characters of the lasiocampid larvæ are: Head dull, i.e., not glossy; head and body covered with simple hairs, the hairs not in discrete tufts; body smooth. The larvæ spin cocoons on the host or adjacent trees. Overwinter in egg stage.

Tolype dayi Blkm. *Pseudotsuga taxifolia, Tsuga heterophylla*; Vancouver Island. LARVA: 1½ inches; wide and flattened, flecked in pastel shades of brown and grey, light subdorsal and supraspiracular patches; subspiracular lappets with clumps of long fine hair, hair shorter and less dense on remainder of body; humped tubercles on subdorsum of each segment, largest on T3 and A8; transverse orange fold on dorsum of T3; venter pinkish with dark blotches shaded to orange.

Tolype laricis Fitch. *Larix occidentalis*, Vernon; *Pseudotsuga taxifolia*, Barriere.

Malacosoma pluviale (Dyar). Western tent caterpillar. *Prunus*, spp., *Alnus* spp., *Salix* spp., *Amelanchier* spp., *Malus* spp., *Rosa* spp., and other shrubby growth; Southern B.C. and Vancouver Island. Caterpillars form large, unsightly communal tents of silk over the branches adjacent to the leaves on which they are feeding. Eggs laid on twigs of host plant, close to the ground; cemented in a curved mass, seldom forming a complete band about the twig. LARVA: 1¾ inches; head greyish, speckled with black; body blackish; broken, greyish-blue middorsal stripe; orange blotches along addorsal area; greyish-blue blotches on subdorsum; orange, wavy supraspiracular stripe; subspiracular area, orange; hairs orange.

Malacosoma pluviale (Dyar) var.? So far as is known, the geographical ranges of this and the preceding form are separate.

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Limited to *Betula glandulosa* and *Salix* spp. bordering swamps and muskegs; Central Interior B.C., 1947—defoliated scrub birch at Aleza Lake; 1950—larvæ abundant near Stone Creek, Cluculz Lake, Wells, and north-east of Isle Pierre; 1951—caused light defoliation at various points in the Prince George area. This species makes communal silken tents similar to *M. pluviale*. Eggs in cylindrical mass about twig, similar to *M. disstria*. The larvæ frequently form communal cocoons; as many as six pupæ are enclosed in a single envelope. LARVA: 1¾ inches; basic markings similar to *M. pluviale*, but very little orange coloration (replaced by black) in most specimens.

Malacosoma disstria Hbn. Forest tent caterpillar. *Populus tremuloides, Populus trichocarpa, Alnus* spp., *Salix* spp., *Betula papyrifera,* and other broad-leaved trees and shrubs; during heavy outbreaks may spread to and damage new growth of conifers; generally distributed. Medium to heavy infestations have been reported at one or more localities in British Columbia during the following periods: 1938, 1941–43, 1945–47, 1949–53. Apparently the most recent of these outbreaks is the largest and most widespread of those occurring during the past fifteen years. No tree mortality has been reported following any of these infestations. The depredations of this species cause considerable concern to tourist-camp operators and home-owners with dwellings within or adjacent to poplar stands. Eggs cemented together in a cylindrical mass about a twig, usually in upper crown of the tree. No tents formed. LARVA: 2 inches; head and body, pale greyish-blue, speckled with black; black-bordered orange subdorsal and supraspiracular stripes; additional orange and black line-markings on dorsum; off-white or cream-coloured blotches along middorsum.

Epicnaptera americana Harr. Lappet moth. *Populus tremuloides, Populus trichocarpa, Quercus* spp., *Salix* spp., *Betula papyrifera, Alnus* spp., *Amelanchier* spp., *Acer* spp., *Corylus* spp., *Crataegus* spp., *Malus* spp.; generally distributed; not recorded in outbreak proportions. LARVA: 2 inches; head and body, hairy; flap-like projections beneath the spiracular area; body greyish, finely speckled with black, some orange spots; two reddish or orange black-edged transverse bands on dorsum of thorax (bands concealed when body contracted); middorsal protuberance on A8; venter flattened, orange with black blotches.

Saturniidæ

The silk moths are relatively unimportant defoliators in this Province. Their large size and the striking coloration of some species attracts much attention from the general public. The larvæ have spine-bearing tubercles or dense groups of spines and branched spines on the thorax and abdomen.

Hyalophora euryalus (Bdv.). Ceanothus silk moth, incorrectly called "Cecropia." *Ceanothus sanguineus, Alnus* sp., *Salix* spp., *Ribes* spp., *Betula* spp., and other deciduous hosts; Southern Interior, Victoria, Saltspring Island, Quesnel. Cocoon, pointed at one end, firmly attached to twig on host tree; overwinters. LARVA: 3¼ inches, stout; head and body, yellowish-green; elongate tubercles, each tipped with small black spines; subdorsal and lone middorsal (A8) tubercles red, those on the meso- (T2) and meta-thorax (T3), and middorsum of A8 ringed with black; tubercles in supra- and sub-spiracular rows, white and bluish, black at bases.

Automeris polyphemus (Cram.). Polyphemus. *Betula papyrifera, Quercus garryana, Alnus* sp., *Prunus* sp., *Salix* spp., *Populus tremuloides;* Vancouver Island, Southern and Central Interior B.C. Cocoon broadly rounded at both ends, usually formed within leaves; as a rule winters on the host tree suspended on the twigs or the trunk. LARVA: About 3 inches; head yellowish-brown; body green; row of elongate tubercles, with pale bristles along subdorsal, supra- and sub-spiracular areas; all tubercles, except the yellow

anterior subdorsal pair, are an orange-red, those above the spiracles with silvery bases; almost vertical cream-coloured line behind red spiracles on A1 to A8; suranal plate edged laterally with purple and white. Larva takes hunched stance when at rest.

Pseudohazis eglanterina Bdv. Range moth. *Salix* spp., *Populus tremuloides, Amelanchier* spp., *Spiræa* spp.; Vancouver Island, Silver Creek, Rock Creek, Vernon. Probably has two-year cycle; overwinters in cocoon or in egg stage. Eggs in mass about twigs. LARVA: 2¼ inches; head, brown, hairy; body, dark brown, paler intersegmental areas; rather obscure, off-white, subdorsal, supra- and sub-spiracular and midventral stripes; row of dense clumps of brown spines along subdorsum; rows of dark-brown branched spines along supra- and sub-spiracular areas; portions of body clothed with fine grey hair.

Liparidæ

Members of this family are defoliators of coniferous and deciduous trees. The caterpillars are hairy, and all but *Stilpnotia* have prominent tufts of plumose hairs. Liparids may be distinguished from the larvæ of other families by the eversible glands (bright red on *Hemerocampa* and *Notolophus*) on the middorsum of abdominal segments 6 and 7. Pupation occurs within thin grey or whitish silken cocoons spun on the leaves, branches, or trunks of the host or adjacent trees. Wings of female *Notolophus* and *Hemerocampa* are rudimentary.

Notolophus antiquus (L.). Rusty tussock moth. *Alnus* spp., *Salix* spp., *Betula papyrifera, Acer* sp., *Malus* spp., *Tsuga heterophylla, Pseudotsuga taxifolia, Picea engelmanni, Picea sitchensis, Larix occidentalis, Abies lasiocarpa, Abies grandis, Thuja plicata* (two records), *Pinus contorta* (two records); generally distributed; occasionally numerous. Overwinters in egg stage. LARVA: 1 inch; head, glossy black; dorsum of body, grey with black dorsal stripe, narrow on thorax, broad on abdomen (body may be almost entirely blackish); orange tubercles; brush-like tufts of cream or buff-coloured hair on segments A1 to A4 (in early instars, the first two tufts are black, last two are pale); a long pencil of black plumose hairs on A8, and similar lateral pencils on T1; females have an additional lateral pencil-tuft on A2.

Hemerocampa pseudotsugata McD. Douglas-fir tussock moth. *Pseudotsuga taxifolia;* this species may spread to other coniferous hosts during an infestation. Southern Interior. Outbreaks in the Southern Interior occurred during the following periods: 1918–22, 1928–31, 1938–39, and 1946–49. In most infestations heavy defoliation on a given area apparently was limited to one or two years. Overwinters in egg stage. LARVA: 1¼ inches; head, glossy black; body, hairy, grey and black with broken orange-yellow subspiracular stripe; red tubercles; two prominent black lateral pencil-tufts on T1 and one black dorsal pencil-tuft preceded by a shorter recurved rust-coloured tuft on A8; a dense rust-tipped brush-like tuft on dorsum of each segment A1 to A4; venter pale. Contact with the larval hairs of this species causes a skin rash on some persons.

Parorgyia styx (B. & McD.). *Tsuga heterophylla, Pinus monticola* (two records); Coastal B.C. and Vancouver Island. *Parorgyia* spp. have a two- or three-year cycle. LARVA: 1½ inches; dark brown; prominent brush-like clumps of mole-grey hair on dorsum of A1 to A4; very long pencil-tufts of dark clubbed setæ on subdorsum of T1 and A9, single tuft on dorsum of A8; balance of dorsum with tufts of long yellowish setæ, more dense subdorsally on T3 and A5; interspersed with longer clubbed dark setæ subspiracularly.

Parorgyia grisefacta (Dyar). *Pseudotsuga taxifolia, Tsuga heterophylla, Picea engelmanni, Picea glauca, Abies lasiocarpa, Larix occidentalis, Pinus contorta;* Interior B.C.; no infestations recorded. Overwinters in the larval stage.

LARVA: 1¾ inches; head, dark brown; dorsum of T1 and A5 to A10 rusty-brown; sides of body, occasionally whole body, blackish; a long black pencil-tuft on the dorsum of A8 and similar lateral paired pencil-tufts on T1 and A9; shorter tufts of plumed black hairs along the supra- and sub-spiracular areas; dirty white brush-like tufts on dorsum of segments A1 to A4; numerous short, white plumed hairs in most of the setal tufts on body above spiracles.

Stilpnotia salicis (L.). Satin moth. *Populus tremuloides, Populus trichocarpa, Salix* spp. (*Populus nigra* and *P. alba*—exotic species). An introduced insect, first discovered at New Westminster during 1920; spread to Vancouver Island by 1932, and up the Fraser River as far as Clinton and east along Thompson River Valley to Bestwick by 1953. During 1944 and 1945, cottonwoods at Botanie Valley, near Lytton, were defoliated; in 1946 a light infestation was observed at a point 10 miles south of Clinton. During 1949, defoliation occurred in several new localities—Savona, Ashcroft, and Stump Lake in the Nicola Valley. Overwinters as young larva in hibernaculum. LARVA: About 2 inches; head, dull black; body, blackish, with a row of constricted white blotches on the dorsum; broken, white subdorsal line; prominent reddish-brown tubercles bearing clumps of brownish hairs on upper portions of the body.

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ANNOTATED LIST OF FOREST INSECTS OF BRITISH COLUMBIA PART II—*LASPEYRESIA* SPP. (OLETHREUTIDÆ)*

D. A. Ross†

Some species of *Laspeyresia* are economically important cone-borers and seed-feeders, others are bark-miners of undetermined economic significance. Few adults of the latter group have been reared during the course of Forest Insect Survey investigations in British Columbia.

Characters common to full-grown *Laspeyresia* larvæ in the following list are: Length, two-fifths to three-fifths of an inch; head brownish, partially retracted into the thorax; body, pale cream-coloured or whitish; body setæ minute; ventral proleg crochets in complete oval or ellipse; thoracic legs small.

L. bracteatana (Fern.). *Picea sitchensis* cones, Queen Charlotte Islands. Heinrich saw the specimens that established this record and stated that they were best placed as *bracteatana*.

L. rana Forbes. One specimen in Vernon reference collection, B.C. Survey No. 41-3082, with no data. This species mines bark of *Picea engelmanni*. (Heinrich 1926.)

L. youngana (Kearf.). *Picea glauca* cones; Central and Northern Interior; Whitehorse, Carcross, Yukon Territory. Occurred in infestation proportions in several areas during 1952 and 1953. Larva bores through scales, seeds, and rachis of cone; overwinters in cone, and pupates in spring. LARVA: Three-eighths of an inch long; pale cream-coloured.

L. piperana (Kearf.). *Pinus ponderosa* cones, Grand Forks.

L. miscitata Hein. *Pinus ponderosa* cones; Southern Interior. Apparently this species is much commoner than *piperana*, which it resembles very closely in appearance and habits. The larvæ burrow through the scales and seeds; often feeding does not prevent the complete opening of mature cones.

About 80 per cent of the cones on some trees sampled in the Kamloops Forest District were infested each year during the period 1950 to 1953. From one to six late-instar larvæ have been found in individual cones. Larvæ overwinter in the rachis of the cone and pupate in the spring. LARVA: Three-fifths of an inch long.

Laspeyresia spp. Two species (one noted by Walters 1953) other than those listed above, mine *Pinus monticola* bark in Southern B.C. One has been determined as *L.* sp. probably *obnisa* Hein. The other species is close to *piperana*.

Acknowledgment

The writer is indebted to Dr. T. N. Freeman for identifying most of our specimens in the genus *Laspeyresia*.

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SEXING AND RECLAIMING DRIED SPECIMENS OF *DENDROCTONUS ENGELMANNI* HOPK.*

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Two techniques which may not be widely known were recently brought to the attention of the writer. One, which does not destroy the living beetles or specimens, is a rapid method for determining the sex of adults of some species of *Dendroctonus*. The other is a method for reclaiming dried or pinned specimens for histological study. The use of these techniques on adults of *Dendroctonus engelmanni* Hopk. is reported in this paper.

Several years ago it was necessary to determine the sex of a number of Engelmann spruce beetle adults. At that time a description of the external characteristics which satisfactorily separated the sexes could not be located, and it was necessary to dissect the specimens. The presence or absence of the dark-brown forked spicule of the male provided the most rapid method of confirming the sex.

Recently, Mr. V. McCowan, entomologist for Weyerhæuser Timber Company, was able by touch to determine accurately the sex of over 400 adults of *Dendroctonus pseudotsugæ* Hopk. This technique can be used successfully with *D. engelmanni*. To establish the point, a collection was used of 105 specimens from Bolean Lake, pinned in 1950. These specimens were examined first by touch, then externally under the microscope, and, finally, internally.

Irregularly scattered over the interstrial spaces of the elytral declivity of the female are a number of tubercules. These are most numerous adjacent to the elytral suture and can be felt readily. The tubercules were rarely present on the elytral declivity of the male.

To determine the sex of a specimen, a finger is run backward and downward over the caudal portion of the elytra so that the feel of the tubercules is not confused with that of the hairs and bristles. The elytral declivity of the female feels like fine emery paper, whereas that of the male feels like talc.

After determining the sex of each specimen as described above, the presence of tubercules was noted. The sex was confirmed by dissection. Sixty-eight of the specimens were female. Two of the specimens were incorrectly sexed by touch; both were males and both had prominent tubercules.

Before dissection, the specimens were first soaked for two hours in a 0.5-per-cent solution of tri-sodium phosphate. The writer is indebted to Dr. J. A. Chapman for drawing his attention to this technique of van Cleave and Ross for reclaiming dried specimens for histological purposes. These authors report that the solution restores the normal appearance of small invertebrates, making them relatively soft and pliable without showing any dissociation of tissue. This was borne out in the present investigation. After treatment it was possible to examine the gut for food content, to determine the number of eggs present, and to identify the various reproductive structures. The tissues were pliable but not fragile.

One of the interesting sidelights of the examination was the discovery of nematodes in a large number of the specimens. Where present they were usually very numerous and densely packed ventrally in the abdominal cavity and in the vicinity of the proctodæum. The adults of 43 per cent of the seventy-five galleries represented by the collection were infested.

* Contribution No. 139, Division of Forest Biology, Science Service, Department of Agriculture, Ottawa, Canada.

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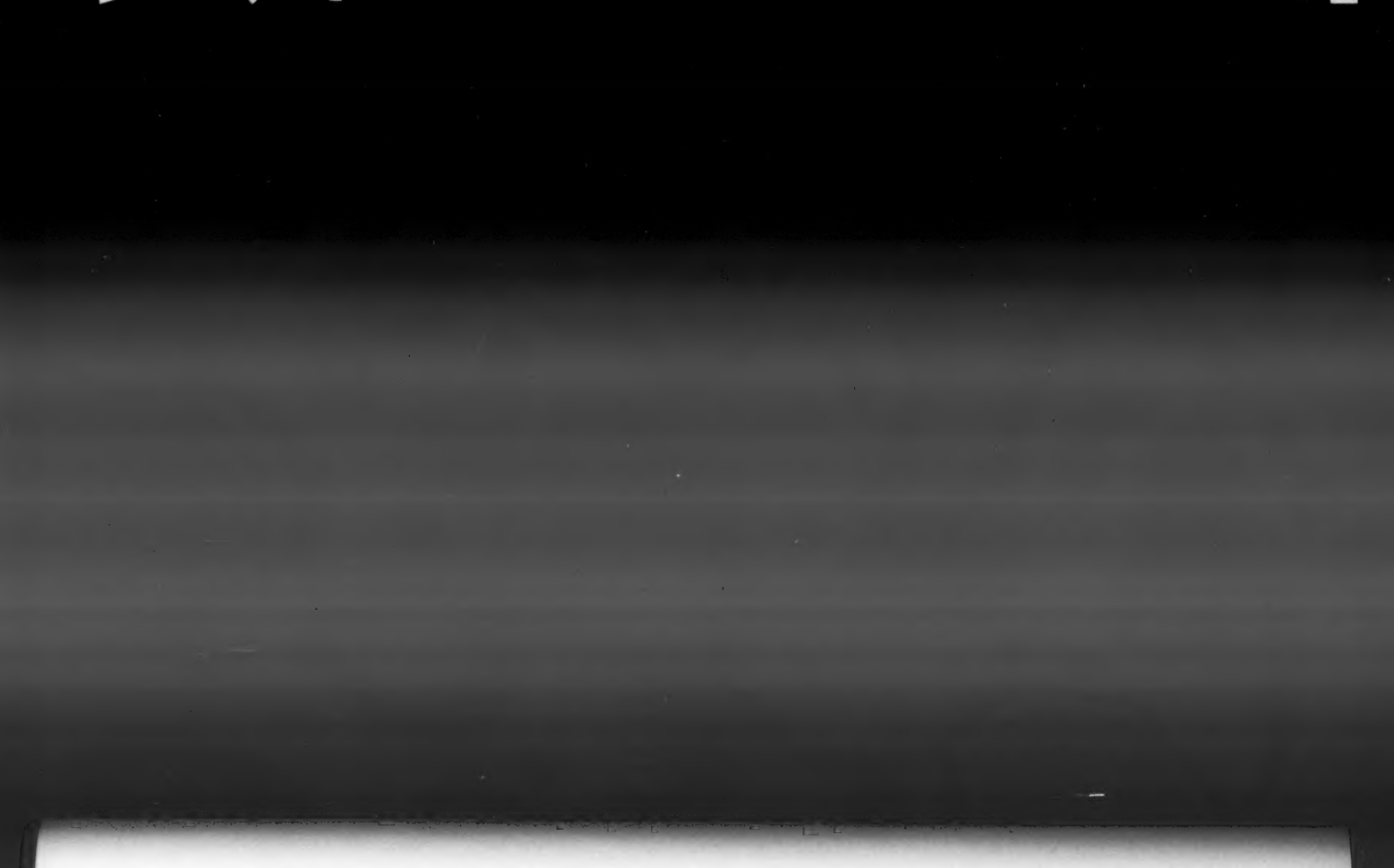
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